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COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

IMPLEMENTATION OF THE RECOMMENDATIONS OF THE SECOND UNITED NATIONS CONFERENCE ON THE EXPLORATION AND PEACEFUL USES OF OUTER SPACE

International cooperation in the peaceful uses of outer space: activities of Member States

Note by the Secretariat

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INTRODUCTION

1. The Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), in the report on the work of its eighth session (A/AC.105/571, annex II), made recommendations concerning the preparation of reports and studies by the Secretariat and the compilation of information from Member States.

2. In paragraph 10 of its report, the Working Group recommended that, in the light of the continued development and evolution of space activities, the Committee on the Peaceful Uses of Outer Space should request all States, particularly those with major space or space-related capabilities, to continue to inform the Secretary-General annually, as appropriate, about those space activities that were or could be the subject of greater international cooperation, with particular emphasis on the needs of the developing countries.

3. The report of the Working Group was adopted by the Scientific and Technical Subcommittee at its thirty-first session (A/AC.105/571, para. 22), and the recommendations of the Working Group were endorsed by the Committee on the Peaceful Uses of Outer Space at its thirty-seventh session.[1]

4. Subsequently, in a note verbale, dated 13 July 1994, from the Secretary-General to all permanent representatives to the United Nations, the Secretary-General requested all Governments to communicate to the Secretariat, by 30 November 1994, the information requested in the above-mentioned recommendations.

5. In addition, the Secretary-General, in his note verbale, drew the attention of Governments to the following recommendation of the Committee that the Secretariat should invite Member States to submit annual reports on their space activities. In addition to information on national and international space programmes, the reports could include information in response to requests from the Working Group of the Whole as well as information on spin-off benefits of space activities and other topics as requested by the Committee and its subsidiary bodies.[2]

6. In accordance with the recommendation of the Committee, the Secretary-General, in his note verbale, suggested that Governments could submit in a single report on national space activities information in response to those requests, as well as information on topics as requested by the Working Group, in particular information on the following topics:

(a) Those space activities that were or could be the subject of greater international cooperation, with particular emphasis on the needs of the developing countries;

(b) Spin-off benefits of space activities;

(c) National and international research concerning the safety of nuclear-powered satellites;

(d) Studies conducted on the problem of the collision of nuclear power sources with space debris;

(e) National research on space debris.

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[1] Official Records of the General Assembly, Forty-ninth Session, Supplement No. 20 (A/49/20), para. 29.

[2] Ibid., para. 143.

7. The present document was prepared by the Secretariat on the basis of information on the topics listed in subparagraphs 6 (a) and (b) above, received from Member States by 30 November 1994. Information received subsequent to that date will be included in addenda to the present document. Information received regarding the topics listed in subparagraphs 6(c) to (e) above is presented in a separate document (A/AC.105/593).

REPLIES RECEIVED FROM MEMBER STATES

AUSTRIA

[Original: English]

The Austrian report presents Austria's activities in space research and some related fields. These activities are largely collaborative efforts with other countries or international organizations. The funds of the various space activities are provided by the Federal Ministry for Science and Research and distributed to the individual institutions through the Austrian Academy of Sciences and the Austrian Research Foundation (Österreichischer Fonds zur Förderung der Wissenschaftlichen Forschung). Other projects were carried out under the European Space Agency (ESA) contracts. Austria became a full member of ESA on 1 January 1987.

A. Liaison and coordination

Austrian Space Agency, Vienna

The Austrian Space Agency (ASA), which was established in 1972, serves the Federal Ministry of Science and Research as a focal point for the coordination of space activities in Austria. According to the terms of references of ASA the main tasks are as follows:

- To coordinate projects in the field of space research and technology in Austria and other countries, as well as within the framework of international agreements and organizations.
- To establish and maintain contacts with foreign institutions engaged in space research and technology.
- To advise the Austrian Government on matters concerning space research and technology in line with Austrian interests and requirements, taking into account international developments in this area.
- To process and distribute information and data on space research and technology to all interested parties in Austria, as well as to publish relevant documents.
- To promote the training of specialists in the field of space research and technology, in cooperation with university institutes and research organizations within Austria and other countries.
- To carry out public relations activities, in particular the organization of relevant meetings.
- To promote the awarding of contracts to industrial and scientific institutions in Austria.
- To act as the secretariat for the Advisory Committee on Space Research and Technology of the Austrian Government.

It is the task of ASA, which does not own research facilities, to support and promote the activities of existing scientific and industrial institutions in the field of space research and technology.

Coordination of activities related to ESA programmes

In addition to the involvement in the mandatory programme (general activities including general studies, the technology programme and the science programme), Austria participates in the following optional programmes:

- Earth Observation Programme:
  - European Remote Sensing Satellite ERS-1
  - European Remote Sensing Satellite ERS-2
  - Earth Observation Preparatory Programme (EOPP - Extension)
  - Polar Orbit Earth Observation Mission (ENVISAT-1 and METOP)
  - Meteosat Second Generation (MSG)

- Programme for the Development of Scientific Experiments (PRODEX)
- General Support Technology Programme (GSTP)
- Telecommunications:
  - Telecommunications Satellite Olympus
  - Advanced Systems and Technology Programmes (ASTP)
  - Payload and Spacecraft Development and Experimentation Programmes (PSDE)
  - Data Relay Technology Mission (DRTM)
  - Advanced Research in Telecommunications Systems (ARTES)
- Space Transportation Systems:
  - Ariane 5 Development Programme
  - Future European Space Transportation Investigation Programme (FESTIP).

Staff members of ASA attend the meetings of the relevant programme boards to represent the Austrian interest in these activities.

A general evaluation of Austria's collaboration in ESA activities shows satisfactory results. The industrial return coefficient calculated by ESA for all countries, showing the geographical distribution of contracts awarded, amounted to 1.05 for Austria as of December 1993. Of these contracts, 85.9 per cent were awarded to Austrian industrial companies and 14.1 per cent to universities and scientific research institutions.

Remote sensing activities

An ASA working group on remote sensing is continuing with tasks concerning information exchange and promotion of remote sensing activities in Austria. ASA acts as the National Point of Contact (POC) for the distribution of remote sensing satellite data in close cooperation with the Earthnet programme of ESA and EURIMAGE. ASA possesses a data file of all Landsat images (in the form of photographic quicklooks) taken over Austrian territory. ASA is a member of the European Association of Remote Sensing Laboratories (EARSeL) and has acted as national representative since June 1989.

Coordination of bilateral space activities

Basic agreements without financial obligations and without exchange of funds exist between ASA and the National Aeronautical and Space Administration (NASA) of the United States of America and with the space authorities of France, Germany, Norway, Sweden and Switzerland, and serve as a basis for cooperation. Joint space projects can be based on these agreements.

United Nations

ASA is actively participating in the work of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) and its Scientific and Technical Sub-Committee. In the last quarter of 1993, the Office for Outer Space Affairs moved from New York to Vienna. Main topics on the agenda are the applications of remote sensing from space for the needs of developing countries, the future utilization of the geostationary orbit, the safe use of nuclear power sources in space and the protection and monitoring of the environment including space debris.

International Astronautical Federation

ASA is a voting member of the International Astronautical Federation (IAF). The Managing Director of ASA is member of several IAF committees. The 1993 IAF Congress was held at Graz and devoted to the topic "Challenges of space for a better world".

B. Research institutes

1. Austrian Academy of Sciences, Space Research Institute, Graz

Department of Experimental Space Research

Project Cluster

The Space Research Institute is involved with experiments in four major spacecraft missions. The four-spacecraft mission Cluster is carried out jointly by ESA and NASA. It is aimed at probing the Earth's plasma environment with four identical spacecraft on almost identical orbits. Its primary scientific objectives lie in the analysis of boundary layers and wave fields in the plasma environment near the Earth in three dimensions. In 1993 and early 1994, the manufacturing of instrument hardware for four payloads had its most active phase. It is currently being followed by an extensive test period of the spacecraft with the experiments.

Austria contributes hardware to Cluster for two experiments: an instrument to actively control the floating potential of the spacecraft with respect to the ambient plasma, called an active spacecraft potential control (ASPOC), and a fluxgate magnetometer (FGM).

Electrical charging of the outer surface of a spacecraft has serious effects on measurements of the cold plasma. ASPOC uses ion emitters of the liquid metal ion source type for charge neutralization. The development of ASPOC occupied a significant fraction of the Department's resources in 1993/94. This activity can also be regarded as a continuation of earlier investigations related to spacecraft charging and the participation in active experiments with charged particle beams from sounding rockets and Spacelab. ASPOC is being built by an international consortium headed by the Space Research Institute with contributions from the Research Centre at Seibersdorf (Austria), the Space Science Department of ESA/European Space Technology Centre (ESTEC), Norwegian Defence Research Establishment, University of New Hampshire (Durham), Naval Postgraduate School (Monterey, California) and the Jet Propulsion Laboratory (Pasadena, California).

The main objective of the magnetic field investigation on Cluster is the study of small-scale plasma structures. For this purpose, the Department provides analogue multiplexers and 16-bit A/D converters for an FGM. These hardware components have been built, tested and delivered to the Principle Investigator of ASPOC. The Department also contributes with the development of test facilities for the magnetic cleanliness programme of Cluster.

The preparation of the Austrian share of the Cluster science data system, which will provide access to key parameters of the mission to the space community, is also part of the activity at the Department. The Austrian node of this system, which will be located in Graz, will produce its agreed part of the database and provide all services of this system user in Austria. Through this system the Principal Investigator will also have access to the Cluster data distribution system for checking the instrument performance.

Project MARS-94

The constellation between Earth and Mars favours the launch of Mars missions in 1994 or 1996. The then Soviet Space Research Institute (IKI) initiated an international effort called MARS-94 with two almost identical spacecraft. Both missions have now been postponed to the second launch window (1996). Austria is participating in both missions with hardware, namely, the experimental MAREMF, a package dedicated to measure magnetic fields and electron spectra, MAGBAL, a fast magnetometer to measure aboard a martian balloon, and MARIPROBE-D, a multi-purpose, directional plasma probe. The latter instrument is being built in cooperation with the Department of Communications and Wave Propagation of the Technical University

of Graz. All of the above instruments are cooperative efforts with one or more institutes from Belgium, Czech Republic, France, Germany, Hungary, Ireland, Russian Federation, or United States of America.

Project INTERBALL

The mission INTERBALL consists of two pairs of satellites, one in a fairly low orbit (apogee 20,000 km) and the other with an apogee of 200,000 km. These two very different orbits were chosen in order to cover the auroral and the tail regions of the Earth's magnetosphere, respectively. Each of these large satellites will be accompanied by a small subsatellite in order to allow differentiation between spatial and temporal effects. Aboard the low-apogee main satellite the potential will be controlled by an instrument SPEX, similar to ASPOC in the Cluster mission. The goal of SPEX is the stabilization of the spacecraft potential in order to provide accurate measurements of the cold plasma components. SPEX is a joint project of the Space Research Institute and the Research Centre Seibersdorf in collaboration with the Space Science Department of ESA/ESTEC.

Project Cassini/Huygens

The joint NASA/ESA mission Cassini/Huygens to Saturn and its moon Titan, planned to be launched in 1997, will include a lander. In a cooperative project with institutes in France, Italy, Spain and ESTEC, an experiment package, HASI, is being prepared that will measure physical and electrical parameters of the atmosphere in the descent phase starting at an altitude of around 170 km down to surface. The main experiment topics are measurement of the natural AC- and DC-fields, permittivity, acoustic fields and electrical relaxation time constant during descent and hopefully after impact. At lower altitudes also data processing for an onboard altitude radar will be performed. If the capsule survives the landing, it will also carry out measurements on Titan's surface.

Austria also contributes significantly to another experiment, the Aerosol Collector Pyroliser (ACP). According to observations from the ground and from the fly-by of the spacecraft Voyager, Titan is expected to have a nitrogen-methane atmosphere with aerosols in it, probably as a result of the polymerization of carburetted hydrogen. The ACP experiment is designed to collect, heat and analyse atmospheric aerosols in the Titan stratosphere and upper troposphere during the descending phase of the Huygens capsule.

Among the primary scientific objectives is the determination of the composition of the aerosols and the relative abundance of its constituents, the relative abundance of condensed organic compounds, the mean size of aerosol nucleation sites and the radiative properties of low stratospheric and upper tropospheric particles.

The Principal Investigator for the ACP instrument is from the Service d'Aéronomie, CNRS, Paris. Austria is responsible for the development of the very complex flight electronics, the software and the complete ground-test equipment. The Austrian hardware contribution is performed under the ESA-PRODEX programme. The Space Research Institute is responsible for the technical coordination; Austrian Industries, Joanneum Research and Schrack-Aerospace are the contractors responsible for design, manufacture and tests.

The ACP complex consists of an aerosol-collecting target, exposed to Titan's atmosphere during the descent of the ESA Huygens probe. The collected aerosols will be pyrolized in an oven and the evaporates transferred to the gas chromatograph/mass spectrometer (GCMS) instrument for further analysis. The complex dedicated electronics to control this system is the contribution of Austria. The Cassini spacecraft is expected to be launched in October 1997. Upon arrival near Titan in the year 2004 the Huygens probe will be separated from the Cassini spacecraft to enter Titan's atmosphere.

Of the results of past missions, the one to Halley's Comet is still of prime interest. In a cooperative study with NASA (Goddard Space Flight Center (GSFC)) and IKI (Moscow), the relevance of solar wind

structures, changes in the interplanetary magnetic field (IMF) to what are called disconnection events (detachment of the comet's plasma tail) were studied. Combined in situ and ground-based measurements revealed no correlation between the two phenomena, which contradicts earlier computer simulations. Another topic of interest of the observations of Halley's Comet is the modulation of particle fluxes observed by both the VEGA and Giotto spacecraft. It hitherto only appears certain that the modulation is not exclusively caused by magnetic field variations. The numerical simulation showed the formation of condensations in the plasma tail after a 90° change in IMF sweeping over the comet.

Projects Phobos and VEGA

The mission Phobos to Mars and its moon Phobos provided data with a hitherto unavailable time resolution and data from regions near Mars which had never been explored before. The correlation between solar wind parameters and boundary parameters were investigated in more detail. It became apparent that the Martian magnetospheric tail depends on the solar wind dynamic pressure in a similar way to that of Earth - another confirmation of the hybrid character of the solar wind-Mars interaction. In view of the interpretation of observations obtained by the two plasma packages TAUS and ASPERA on board Phobos 2, a comparative study of particle and magnetic field data was initiated. The numerical model of the magnetosheath was extended by the incorporation of a draped field geometry within the tail, thus allowing the computation of the plasma flow and magnetic field at any point around Mars. Test particles were launched in these prescribed fields and their statistical properties analysed. The preliminary results are in reasonable agreement with the measurements, thus suggesting the draped field to be a meaningful approximation to the real Martian wake.

Based on data of the experiments MAGMA and SLED, the dynamics of pick up ions with energies above 55 keV were investigated as well as the influence of the moon Phobos on the propagation of high energetic particles.

The search in the magnetic field data of the MISCHA experiment aboard spacecraft VEGA 1 and 2 for phenomena in the solar wind, which are thought to be relevant to processes in the coma of Halley's Comet, was continued. It turned out that for such studies the simulation of disturbances in the solar wind is indispensable. In a joint project with the University of St. Petersburg, in the Russian Federation, an MHD code which is capable of advancing perturbations in the solar wind from the solar surface into the interplanetary space was implemented on the computer of the Institute. The first results have already proved the usefulness of the code for simulating the location of sector boundaries.

By means of multi-spacecraft analysis based on data from VEGA 1 and 2, PHOBOS 1 and 2, PVO and IMP 8 a special magnetic field structure known as "magnetic cloud" could be identified.

Department of Extraterrestrial Physics

The Department of Extraterrestrial Physics is involved primarily in theoretical but also experimental research covering the interaction between the solar-wind and solar-system bodies, and detailed magnetospheric processes such as planetary radio emissions, magnetic field reconnection, solar terrestrial relationships and planetary aeronomy, as well as the physics of comets.

Planetary radio emission

The project investigating the Jovian decametric radio emission (DAM) in cooperation with the Nancay Observatory in France and the Kharkov Observatory in the Ukraine analysed ground-based spectrometric measurements of millisecond radio bursts (S-bursts) with a high spectral resolution (2 milliseconds, 20 kHz).

Special emphasis was given to the analysis of the S-burst features, drift rates and inherent Faraday effect with a new opportunity to study ionospheric irregularities by simultaneous measurements by all three stations.

In collaboration with the Observatoire de Paris, Meudon, France, the source location of Jovian radio emissions was analysed by the means of direction finding. The Ulysses URAP experiment provides the unique possibility of deducing Stokes parameters which lead to source location. Fundamental studies have been performed to obtain knowledge on inherent errors.

New investigations have been performed with regard to our participation in the Radio and Plasma Wave Science (RPWS) experiment within the frame of the Cassini mission. Studies on the rheography tests yield information on the electric plane of the Cassini spacecraft antenna system. A 1:30 model of the Cassini spacecraft was brought into a homogeneous electric field in a water-filled tank. By turning the model around three axes the antenna pattern could be determined, which, due to the spacecraft body, deviates significantly from the nominal structure. Main emphasis is, from the knowledge of the electric plane, the determination of the wave characteristics (direction, polarization, intensity) and the radio source locations of the Saturnian Kilometric Radiation (SKR).

Planetary aeronomy

Previous calculations of the potential for pressure balance between the solar wind and the ionospheres of the weakly magnetized planets, Mars and Venus, indicated that the maximum or peak ionospheric thermal pressure is sufficient to stand off the solar wind at Venus, but not at Mars. Radio occultation measurements of electron density profiles from Mariner 6 and 7, the Mariner 9 extended mission and the United States Viking orbiters, together with model ion and electron temperature profiles, were used to derive thermal pressure profiles in the Mars ionosphere. Similarly, Pioneer Venus Orbiter radio occultation data and temperature models were used to obtain ionospheric pressure profiles at Venus. The comparison of the Mars peak ionosphere pressures with the incident solar wind dynamic pressure suggests that at solar maximum the Mars ionosphere, like that of Venus, should generally be sufficient to balance the incident solar wind pressure. At solar minimum, when the ionosphere is weakest and the solar wind dynamic pressure is highest, only the peak pressures at high solar zenith angles at Mars appear to be strong enough to balance the incident solar wind pressure. This is similar to the situation at Venus at solar minimum. These results are somewhat contrary to the frequent assumption that the Mars ionosphere is everywhere and always too weak to withstand the incident solar wind dynamic pressure. When the solar zenith angle dependence of both the incident solar wind pressure and the peak electron density, and the solar cycle variation of the ionosphere, are taken into account, however, the situations at Mars and Venus appear to be quite similar.

In the study of atmospheric loss processes from Mars and Titan, energy flux spectra and particle concentrations of the hot oxygen and nitrogen, resulting primarily from dissociative recombination of molecular ions, have been investigated by means of the Monte Carlo method. Mass loss via solar wind and magnetospheric wind interaction was also estimated using newly calculated mass-loading limits. For Titan, the consequences of different ionization and dissociation source models of molecular nitrogen for the escape of atomic nitrogen and the presence of a nitrogen corona were investigated. Further, the molecular hydrogen distribution in Titan's exosphere and the molecular hydrogen escape, including the effects of a high and low altitude homopause, were also calculated. The mass loss of nitrogen is much less than previous estimates, which may have important implications for the argument of argon being the missing constituent in Titan's atmosphere. The erosion of Titan's nitrogen atmosphere resulting from sputtering, due to energetic particles occurring when Titan is either in the solar wind or in Saturn's magnetosphere, however, appears to be more important. The total atmospheric mass loss over the age of the Solar System by sputtering would amount to about 20 per cent of the present atmospheric mass of Titan. In contrast to impact ionization/dissociation, there will be no extended atomic nitrogen corona present above Titan since, because of sputtering, the excess

energy primarily leads to escape and supply to the Saturn system rather than to ballistic orbits. Sputtering will yield, however, a small molecular nitrogen corona of Titan.

For Mars, a model to investigate the transport of the upward-flowing heavy molecular ionospheric ions on the Martian dayside and night-side polar magnetosphere into the solar wind interaction region has been developed. Ion trajectories in the polar regions, for a range of injection conditions of the convection electric field, gravitation and the magnetic gradient force by using a three-dimensional magnetospheric model were calculated. The effect of collisions with the neutral oxygen atoms and the possible effect of external parallel electric fields or instabilities and the dependence of the plasma escape on the Martian magnetopause and the solar wind ram pressure were also investigated. The calculated parallel escape fluxes of heavy ions are compared with the Phobos 2 measurements and other theoretical calculations. These calculations imply an upper limit of an intrinsic magnetic moment. Outflow of heavy molecular ions is only possible during disturbed solar wind conditions and the observed heavy molecular ion escape provides evidence for a weak intrinsic magnetic field of Mars.

Thermal histories of the Neptunian satellite Triton and the Planet Pluto were constructed by assuming that they formed as homogeneous ice-clathrate-silicate mixtures. The models include effects of accretional and radiogenic heating: conductive and subsolidus convective heat transfer suffices to provide the melting of the clathrate and the formation of liquid shells around the silicate cores. Migration of buoyancy driven fluid-filled cracks leads to explosive events and outgassing of methane, ammonia and other volatiles at the surface.

Solar wind magnetosphere coupling

Several problems of the interaction of the solar wind with the magnetosphere have been successfully treated through international cooperation with the University of St. Petersburg (Russian Federation), University of Sussex (United Kingdom of Great Britain and Northern Ireland), NASA/GSFC (Maryland, United States), Russian Academy of Sciences in Krasnoyarsk, University of Buenos Aires (Argentina) and University of Malta.

The model of stationary reconnection of magnetic fields developed in the last few years has been compared with different experimental data from spacecraft missions. Moreover, a time-dependent model of reconnection has been further developed. The model is now capable of describing localized reconnection of skewed magnetic fields. This proposes a theoretical foundation for what are called "flux transfer events", which represent a common feature in experimental data. In addition, within the same description, surface waves and the erosion of the magnetopause can be modelled.

Another field of investigation involved the study of three-dimensional stagnation point flows near current sheets. In this context the dissipative MHD equations have been reduced to ordinary differential equations for special geometries occurring at the magnetopause. Especially the influence of viscous forces on the plasma parameters has been studied extensively. The magnetic field and plasma behaviour in the magnetosheath have been calculated with consistent influence of the magnetic forces on the plasma flow. Finally, time-dependent reconnection models for non-homogeneous magnetic fields have been developed. In addition, a shear in the velocity has been included in the model, which applies to the near-cusp region.

Cometary physics

In the field of cometary physics the main effort has been the investigation of physical processes that take place in the surface layers of cometary nuclei. In addition to experiments performed at DLR/Cologne, a small vacuum laboratory was installed at the Department that allows a more extended series of experiments to be performed. Measurements were made of heat transfer in porous ice samples both for water ice with different

pore sizes and for ice/mineral mixtures (water ice, carbon dioxide ice, minerals). The main effort concentrated on the determination of heat conductivity of sublimation residua as a function of their content of organic matter. Furthermore, theoretical studies concerning heat transfer in multi-component ices and the interaction of nonvolatile particles with an icy environment have been performed. In multi-component ices a chemical differentiation of the components takes place.

Department of Satellite Geodesy

Following the general objectives of the Department, which aim at a valuable geodetic contribution to the Global Change programme and the International Decade for Natural Disaster Reduction (IDNDR), considerable work has been carried out to meet the requirements for high-precision investigations, which are a prerequisite for monitoring the slow movements of the Earth's crust, instantaneous changes caused by seismic events and the rapid change of the sea surface topography. Basic to all such investigations is the realization of a dynamic international terrestrial reference frame (ITRF), which consists of a selected number of permanently observing geodynamic observatories and precise satellite orbits in the same ITRF for satellite-borne measurements such as radar altimetry. Changes in ITRF can be attributed to global and regional crustal movements, local monitoring leads to the detection of seismic events, and altimeters measure the actual vertical distance between the reflection target (sea surface etc.) and the satellite in a straightforward manner. In order to link satellite orbits to ITRF (in the frame of international cooperation), the Department of Satellite Geodesy operates the geodynamic observatory Graz-Lustbühel on a permanent basis. It disposes of a ultra-precise Laser Ranging Station (SLR), a permanently recording receiver for the global positioning system (GPS), a transponder unit, software expertise for GPS-, laser- and altimetry-data reduction. It is operating a data centre for serving geodynamic projects within the Central European Initiative and has carried out regional and local investigations for determining the sea surface topography of the Mediterranean Sea, the movement of the Adriatic microplate, as well as crustal motions in the eastern Alps and correlation to local microseismics.

Laser updates and measurements

During the past two years, significant improvements and extensions of the laser installation and measurement techniques have been made that mainly concern the increase of the reliability and the repetition rate of the Laser-pulses and the implementation of a two-wavelength system.

These improvements led to a significant increase of the data density and, thus, to an improvement of the statistical accuracy of measured laser distances to satellites to ± 1-2 mm RMS (± 7 to 10 mm single shot accuracy, dependent on the satellite type). During the last two years more than 2,400 satellite passes were observed to ERS-1, LAGEOS-1, TOPEX, STARLETTE, GPS-PRN 5, ETALON and others as a contribution for precise orbit determination, the International Earth Rotation Service (IERS) and the long-term project Dynamics of the Solid Earth (DOSE).

International global positioning system and geodynamics

The international global positioning system (GPS) of the Geodynamics Service (IGS) was approved by IAG and started its regular operation at the beginning of 1994. The first test phase had been initiated in June 1992, followed by an intermediate "pilot service" starting in October 1992. During that period further permanent GPS observations were carried out at Graz, the data automatically being transmitted to regional and global data centres for orbit computation and determination of the velocity field of ITRF. In collaboration with the Central Institute for Meteorology and Geodynamics (an Austrian contribution to IDNDR), two additional GPS-receivers were acquired to operate permanently at two sites near Innsbruck for investigating possible correlations of local crustal movements with microseismic events detected by four fully automatic seismic stations in that area.

Three epoch-like GPS-campaigns were organized and computed during the past two years. EPOCH '92 was observed at 20 stations in Austria, Bulgaria, Czech Republic, Hungary and Poland during two weeks in July/August 1992. The AGREF-92 campaign comprised 86 sites in Austria, Slovenia and the northern part of Croatia. The resulting coordinates of mostly well-fixed points serve as the basis for future geodynamic investigations in the eastern Alpine area and as the reference for national surveys. Finally, 14 sites along the boundary of the Adriatic microplate were observed in collaboration with national institutions in Albania, Austria, Croatia, France, Greece, Italy and Slovenia during five days in October 1993. The computations are in progress. As most of these sites belong to the Italian "Tyrgeonet", which was repeatedly measured but with lower accuracy, the comparison may give indications of movements along the boundary of the microplate.

Further activities were related to extensive compatibility tests of different receiver types, which confirm that the combination of different types only marginally degrades the accuracy of baseline computations.

Altimetry

The use of satellite-borne altimeters allows for the determination of the instantaneous sea-surface (footprint) with an accuracy of about ± 5 cm provided that the satellite orbit is known precisely. Moreover, the reflecting sea surface can be replaced by a transponder, a simple device which receives the altimeter signals and returns them after amplification. Such a device can also be used over land, in particular for a rough topography, for precise height transfer, altimeter calibration and orbit computation.

In order to prepare the reduction of actual ERS-1/ERS-2 altimeter data existing test data from previous missions have been validated, catalogued and classified. New programme-modules have been developed for adjusting data at the crossing-points of individual satellite sub-tracks and a digital height model has been generated for the Mediterranean area. Different orbit determination methods and available software-packages have been analysed for a possible extension to a knowledge-based expert-system. A joint proposal for using transponders was forwarded to ESA for approval and to institutes in Denmark and the United Kingdom.

Apart from Department staff additional manpower has been provided by the Federal Office for Metrology and Surveying and additional financial support has been given by the Ministry of Science and Research via the Austrian Academy of Sciences.

2. Natural History Museum, Vienna

Department of Mineralogy and Petrology

As in previous years, research was focused on the following topics:

- Nature and origin of micrometeorites
- Formation and origin of meteoritic chondrules
- Origin of achondritic meteorites
- Petrology and geochemistry of lunar meteorites
- Formation and differentiation of the Earth's upper mantle
- Miscellaneous planetological subjects.

Main research activities were devoted to the study of micrometeorites which were collected by a French team from the Antarctic ice under a programme supported by various French institutions and the European Commission programme EUROMET. With financial support from the Austrian Science Foundation (FWF) an instrumental neutron activation analysis, using an analytical scanning electron microscopic and electron microprobe X-ray analyser, was made of about 80 carefully selected dust particles in the mass range 1-20 µg.

About half of the particles turned out to be of extraterrestrial origin. Most of them had been thermally altered to different degrees during deceleration in the upper atmosphere; some, however, survived atmospheric entry in an almost pristine state. This way, for the first time, the extraterrestrial matter which strongly dominates current accretionary infall on the Earth could be thoroughly characterized mineralogically and geochemically. Although micrometeorites are the most abundant extraterrestrial matter on Earth (infall rate is about 40.000 tonnes/year), their nature had previously been totally unknown because no samples had been available for study. These studies (in collaboration with CSNSM, Orsay, France, and the University of Vienna) yielded the result that micrometeorites are related to the rare classes of chondritic meteorites. The match of all features between micrometeorites and chondrites is not perfect. Part of this mismatch is due to terrestrial alterations of micrometeorites in the upper atmosphere (evaporation and recondensation of certain elements) and at the Earth's surface (leaching of soluble compounds). There exist primordial differences between micrometeorites and carbonaceous chondrites. Consequently, the most common matter currently accreting on the Earth does not match any meteorite in our collections.

3. Technical University of Graz

Department of Communications and Wave Propagation

Upper atmospheric research

The international rocket campaign to study the phenomenon of NoctiLucent Clouds (NLC) of 1991 was repeated in 1993 from ESRANGE, Sweden, relying largely on the recovered and refurbished payloads. The Austrian hardware participation consisted of experiments to measure plasma densities. All instruments worked satisfactorily and good scientific results are expected, particularly in establishing whether the previous measurements from 1991 were typical for NLC or only coincidental. Four payloads for a campaign later in 1994 to study the equatorial middle atmosphere were prepared.

The international satellite project INTERBALL, which was initiated by the former Soviet Union, comprises two large satellites, one in a fairly low orbit and the other will be in a highly eccentric one. As a specialty of this project each of these large satellites will be accompanied by a small subsatellite of the order of 50 kg. They carry instrumentation similar to the one aboard the main satellites and will be at a variable distance (up to a few thousand kilometres away) and thus allow for the separation of spatial from temporal effects. The original concept of these subsatellites was developed by the Geophysical Institute in Prague. The Austrian involvement in these subsatellites came rather late, so that the main participation will be in the data processing and interpretation phase.

The international mission MARS-94, under the leadership of the Russian Space Research Institute, also contains plasma-diagnostic instruments to study the Martian ionosphere. In addition to the novel instrument MARIPROBE-D, a more conventional multi-purpose spherical ion probe (SIP) provided by the Technical University of Graz will be flown. Although SIP cannot yield information on the spatial and energy distribution of ions, it has a much higher time resolution and is, due to its more conventional design, potentially more reliable.

Timekeeping and time transfer

The main aim is to develop and study high precision and accurate time transfer methods using satellite techniques. One-way methods using the signals distributed by the Global Positioning System (GPS) in common-view mode and two-way techniques employing pseudo-noise (PN) signals distributed via communication satellites were investigated.

In order to calculate the path delay of the signals received from the various GPS satellites, as with any one-way system, corrections have to be applied for the propagation delays in the ionosphere and troposphere. The ionospheric delay can be measured using dual-frequency receivers. The tropospheric delay is, for the frequencies used here, frequency-independent and therefore cannot readily be established. Different models are employed in GPS timing receivers using general empirical atmospheric models which only take into account the station height and the elevation of the satellite. For increased accuracy models based on actually measured local surface temperature, atmospheric pressure and relative humidity may be used. At the Technical University of Graz the global positioning system has been used for time transfer purposes since the early 1980s and from that time on together with each measurement (satellite track) local meteorological parameters are recorded. The tropospheric delays obtained from models usually employed in GPS receivers and those using locally measured meteorological parameters were compared with measurements done according to the GPS common-view tracking schedules issued by the Bureau International des Poids et Mesures (BIPM) during the years 1991 and 1992.

In 1993 a two-way experiment started in Europe involving six laboratories in five countries (Austria, France, Germany, Netherlands, United Kingdom).

Satellite telecommunications

Based on the experience of previous experiments an advanced LAN interconnection system is being set up in the framework of the EU project COST 226, supporting multi-media services (digital voice and video in parallel to computer traffic). Compatibility with the emerging broad-band ISDN is important. Therefore asynchronous transfer mode (ATM) techniques are being applied. A new architecture for a flexible satellite access controller, based on true parallel processing has been elaborated. Two TDMA controllers based on transputers have been developed as well as a novel ATM interface for video codes. Multi-media applications (computer traffic in parallel to video conference services) are being tested via satellite. Optimization of the performance of the protocols (TCP/IP) on satellite links have been made.

Such a LAN interconnection system is of high interest for private networks (e.g. for companies and organizations with offices in different countries whose communications needs are not properly met by existing terrestrial networks). Twelve European countries and ESA participate in this activity under Austrian chairmanship.

4. University of Graz

Institute of Meteorology and Geophysics

Ionospheric radio propagation

Measurements of propagation effects on satellite radio signals continued but had to be restricted to the differential Doppler effect on the signals of polar orbiting navigation satellites since no geostationary VHF satellite beacons were available over Europe. These measurements provided continuation for investigations of the latitude dependence of ionospheric total electron content (TEC). The database collected at Graz (mainly from the observing stations Max-Planck-Institut for Aeronomy, Lindau/Harz, Germany and Graz) is used both for long-term studies (e.g. empirical TEC models) and case-studies (e.g. geomagnetic storm effects, investigations of travelling ionospheric disturbances.

The (empirical) European regional TEC model was extended and tested, partly in the frame of the cost-related project prediction and retrospective ionospheric modelling over Europe (PRIME). Some case and campaign studies on ionospheric variability were continued in the frame of Sundial, a project which now provides support to the NASA Atlas missions.

The institute is also a partner in the German-Argentine project for total electron content for upper atmosphere investigations (TECUA). A chain of differential Doppler receivers has already been tested in Europe (Austria, Czech Republic and Germany).

5. University of Innsbruck

Institute of Meteorology and Geophysics

Working Group on Satellite Meteorology and Remote Sensing

The main research activities were concerned with principles and applications of space-borne Earth observation sensors for climate research and environmental monitoring in mountain areas and polar regions. As a basis for the inversion of satellite measurements, active and passive microwave signatures of natural targets were measured during field campaigns in Antarctica and in the Alps.

After the launch of the European remote sensing satellite (ERS-1) in July 1991, research focused on two experiments related to the active microwave instrument (AMI) of this satellite: AO Experiment No. A1 "Snow and ice parameters by means of ERS-1 AMI SAR" with a test site in the Austrian Alps and AO Experiment No. A2 "Active microwave signatures of the polar ice sheets by ERS-1 AMI data". Results of these experiments clearly indicate the high potential of ERS-1 AMI for monitoring snow cover, glaciers and polar ice. Due to the sensitivity of ERS-1 AMI to physical properties of snow and ice and due to regular repeat observations the sensor is able to provide valuable data sets on snow and ice for climatological and hydrological research as well as for operational applications. Research on the application of ERS-1 SAR data for monitoring glacier mass balance and ice dynamics in Antarctica and on the Patagonian Ice Field is carried out in cooperation with the German Alfred-Wegener-Institut for Polar and Marine Research and with the Instituto Antartico Argentino.

The Ötztal region in the Austrian Alps was selected as one of the main test sites for the Spaceborne Imaging Radar-C (SIR-C)/X-SAR Experiment of NASA/DLR/ASI (The High Alpine SAR Experiment). The experiment proposed for this test site is concerned with the development of techniques and with application demonstrations of multifrequency polarimetric Synthetic Aperture Radar (SAR) in the fields of hydrology, glaciology and geology. The first flight of SIR-C/X-SAR took place in April 1994 on board the Space Shuttle Endeavour; the second flight is planned for August 1994. In preparation for these experiments, research on polarimetric SAR signatures and on target classification was carried out based on surveys of the test site Ötztal in 1989 and 1991 with the polarimetric AIRSAR of NASA. In April 1994, five SAR swaths at L-, C- and X-band frequencies were acquired successfully over the Alpine test site with SIR-C/X-SAR.

6. University of Vienna

Institute of Geochemistry

Research has continued in the fields of meteorite research, impact craters, cosmic dust and cosmochemistry. The study of meteorites from Antarctica, especially of lunar meteorites, has also continued. Several new lunar samples were found in Antarctica, and the group participated in the initial characterization and analysis of these meteorites. In addition, a collaborative programme was begun between the Institute, the Natural History Museum in Vienna and CSMSN, Orsay, France. This project is concerned with the recovery and study of micrometeorites from Antarctic blue ice. The French partners are involved in the fieldwork and recovery of the particles, while at the University trace element analyses on particles weighing only a few micrograms are performed. The samples are then transferred to the Natural History Museum for scanning electron microscopy and microprobe analysis.

Another emphasis of the studies concerns the investigation of meteorite impact craters and impact processes. The group has been involved in the study of materials from the Chicxulub crater in Mexico, which was only recently identified to be a 300 km-diameter impact structure in Yucatan, Mexico. This crater is presently covered by about 1 km of sediments, and thus no surface expression is visible. The international consortium has been involved in studying drill core samples from this crater structure. The crater is of special importance because of its 65-million-year age, which is indistinguishable from the age of the famous Cretaceous-Tertiary boundary, which gained notoriety because of the extinction of the dinosaurs. Another crater that has been linked to the Cretaceous-Tertiary boundary is the Manson crater in Iowa, United States. This structure is also covered by later sediments, and has recently been extensively drilled. An international consortium has been formed by the University of Vienna to study a set of core samples from each of the drill holes. This research has helped to decide that impact deposits at the Cretaceous-Tertiary boundary originated from the Chicxulub, and not the Manson, crater.

Further work was done on the study of various other impact craters (e.g. Saltpan and Kalkkop, both in South Africa; Roter Kamm, Namibia; Highbury, Zimbabwe; Ames, United States), as well as tektites (natural glasses that form under rare circumstances during meteorite impact). In one of the more important developments in the field, the group was able to use, for the first time, the rhenium-osmium (Re-Os) isotopic system to demonstrate the presence of an extraterrestrial (i.e. meteoritic) component in tektites and other impact glasses. Most of the research is done in collaboration with various national and international research institutions.

Institute of Astronomy, Section Space Astronomy

Participation in space missions

The Austrian flight hardware contribution for EVRIS, a photometric experiment on board the MARS-94 spacecraft, has been successfully developed, tested and integrated at LAS (Marseille). The simulation of the photometry of target star candidates which are observable from the southern hemisphere has been nearly completed. The project is designed to achieve a noise level of 10^{-6} in the frequency spectrum and should provide a breakthrough in stellar seismology.

Data analyses

Cooperation with the Space Telescope Science Institute in Baltimore, United States, has been established for analysing the photometric stability of HST-guide stars. This investigation takes advantage of the continuous flow of fine guidance sensor (FGS) data while the Hubble space telescope (HST) is pointed to a target object. During the nominal lifetime of the HST of 15 years it is expected that about 20,000 guide stars, selected at random and ranging from 9 mag to 14 mag, will be observed. The scientific goal is to improve knowledge of the variability of field-stars based on a significantly enlarged sample.

Images from the HST data archive were used to investigate cores of elliptical galaxies. These cores provide important clues to the formation and dynamical evolution of the parent galaxies, like recent episodes of star formation, merging and cannibalism and the possible presence of central black holes. By co-adding high spatial resolution images from the HST data archive (planetary camera images) with high signal to noise images obtained at exceptional seeing conditions with ESO NTT and NOT, the signal of the differently resolved images can be consolidated and the resolution of the sharpest one (Lucy algorithm) conserved. This method is used to reveal subcomponents in the central region of the galaxies such as nuclear disks and central point sources.

Supporting ground-based research

Ground-based projects which contribute to the calibration and preparation of space projects are as follows:

- Simultaneous and contemporaneous photometric and spectroscopic observations to ROSAT pointings are currently underway at KPNO and NSO and with an automatic photoelectric telescope (APT) on Mt. Hopkins, Arizona.
- Work on the Deep Near Infrared Survey (DENIS) project continued in close cooperation with the Institute for Astronomy, Innsbruck. Test observations at ESO started in December 1993.
- Ground-based observations in the optical, near IR and mm-range of various classes of cool, mass-losing stars have been carried out, mostly at ESO. The data will serve as preparation and complement to programmes planned with ISO.

Using a newly developed numerical technique of an adaptive grid a large number of radiation hydrodynamical simulations have been performed including the evolution of supernova remnants, the development of cosmic ray driven galactic winds, dust driven winds of pulsating red giants as well as non-linear stellar pulsations of RR Lyrae stars and Cepheids ranging from the stellar interior up to the atmosphere. The calculations on red giants will be applied to observations planned with ISO.

7. Joanneum Research Graz

Institute for Applied Systems Technology

Satellite video conference system

The Institute of Applied Systems Technology in close cooperation with the Department of Communications and Wave Propagation developed a novel satellite video conference system for the European Space Agency in the framework of the Direct Inter-Establishment Communications Experiment (DICE). In contrast to conventional systems it can support multiple sites simultaneously. Special data transmission are provided to distribute documents electronically during the session.

The DICE system is successfully used for technical and management discussions by MATRA-MARCONI using sites in the United Kingdom and France. The most spectacular applications were during the AUSTROMIR space flight in October 1991 and the German MIR-92 mission in March 1992. The mission control centre near Moscow was connected with conference sites in Austria, Germany, the Netherlands and Switzerland contributing significantly to the improvement of the telecommunication infrastructure. Direct links to the space station were set up to allow experts from the remote locations to communicate interactively via satellite with the cosmonauts.

As a result of these successful trials ESA chose DICE as the primary communication medium in support of the EUROMIR-94 and 95 missions. Satellite-based DICE stations have been set up in the Russian mission control centre (CUP), the cosmonaut training centre (CPK) near Moscow, CNES (Toulouse), the ESA Astronaut Centre, Cologne (EAC) and ESTEC (Noordwijk). The MIR telemetry is also available online via DICE from the sites in western Europe. During the flight the experimenters will be able to monitor the conduct of the mission via DICE. The DICE system has been developed further, particularly with respect to lower data rates. A desk-top PC version of the video conferencing equipment has recently been completed.

Radio propagation measurements

Presently propagation measurements at Ka-band are being carried out using the satellite DFS-1. With the modification of the Earth station (under an ESA contract) it is planned to be able to acquire the 20 GHz propagation beacon of Italsat. Mobile propagation measurements at 20 GHz in different environments have been performed in France and the Netherlands by using a mobile beacon terminal owned by ESA. The propagation measurements under mobile conditions will be continued in Austria and Germany. The main objective of this campaign is to derive attenuation statistics in well-defined areas such as urban, suburban and tree-shadowed environments for the precise determination of mobile parameters.

8. Austrian Research Centre Seibersdorf

Department of Physics

Analytical mass spectrometer for materials analysis laboratory on board MIR

The aim of this project is the development of a miniaturized ion microprobe mass spectrometer to be used as a permanent analytical instrument for the material science laboratory on board the Russian space station MIR. Following installation on board MIR, a scientific programme of investigations will be performed in the areas of space degradation of materials (space corrosion), space repairs and general microgravity material science.

This instrument, the Microgravity Mass Spectrometer (MIGMAS), will be the first cosmonaut-operated microanalytical system in space. It should open up new methodology in solving materials-related problems in space technology. On MIR, it will be possible for the first time to offer round-the-clock experimental opportunity at intervals of a few months or even years (so far, it has only been available during short missions). This permanent availability is needed to solve routine problems and continue the development of space material science.

The instrument is already well developed. Essential components have undergone technological tests on MIR during the AUSTROMIR '91 mission and the first complete pre-flight version is fully operative in the laboratory.

This project is in cooperation with the Technical University of Graz and with several institutions in the Russian Federation.

Active potential control of spacecraft

Spacecraft in Earth orbit tend to charge positively with respect to the surrounding plasma due to the photoeffect induced at the outer surfaces by solar UV radiation. Static spacecraft charging can introduce unpredictable distortions and instabilities in on-board sensor data. This positive charging can be compensated for by emitting a beam of positive ions from an on-board ion emitter into space.

A new kind of miniaturized ion emitter has been developed for this purpose, based on field evaporation from liquid metals, the liquid metal ion source (LMIS). Such ion emitters have extremely low mass and power consumption.

Such a charge control system has been operative since August 1992 on the Japanese GEOTAIL satellite. Further missions where the system will be used are INTERBALL (Russian Federation), Cluster (ESA) and EQUATOR-S (NASA/ESA). This project is performed in cooperation with IAS/Graz, ESA/ESTEC and NDRE/Kjeller (Norway).

BELGIUM

[Original: French]

A. Objectives

Through Belgium's participation in European space activities, the Belgian scientific community has been able to take part in scientific projects and experiments at the international, most often the world, level, and Belgian industries - and it is here that most of the fallout occurs - have had an opportunity to become involved in complex projects of a high degree of technological sophistication conducted within a framework of international industrial cooperation.

The history of European space policy is that of a long effort to assure Europe an autonomous position in the areas of launch vehicles and satellites.

From the very outset (i.e. the beginning of the 1960s) Belgium's objective has been to enable the indigenous industry to design and produce, as the sole supplier, certain systems or sub-systems for the European Space Agency (ESA) and the European industrial consortia established around the Agency, and to provide scientific teams with the opportunity to share in the advances in knowledge gained through experimentation in orbit.

For more than 30 years this objective has required the steady pursuit of a strategy consisting of Belgian participation in most of the scientific and application programmes of ESA. It has also required the selection of technology niches as part of a specialization policy formulated through consultation between the State and the industries concerned and based on the opportunities afforded by the Agency's programmes.

The special areas of interest to the Belgian space industry are in particular the following:

- Satellite-borne energy management system
- Ground stations
- Structures and servocommands.

The Belgian scientific community is participating in space research activities in numerous fields, such as:

- Astronomy and astrophysics
- Study of the solar system
- Geodesy
- Meteorology
- Remote sensing
- Life and material sciences under conditions of microgravity
- Hyperfrequencies.

B. Background

Belgium ratified the Convention of the European Space Agency on 3 October 1978. An intergovernmental agreement between Belgium and France, signed on 20 June 1978 and supplemented by two additional agreements signed on 13 November 1984 and 23 October 1991, provides for the participation of Belgian industry in the development of the French satellite remote detection system, the Satellite Probatoire d'Observation de la Terre (SPOT). Under a royal decree dated 15 December 1982, the National Investment Society (SNI) was charged with acquiring, for the account of the Belgian State, an equity interest in the SPOT-IMAGE company, which had been created to market the data provided by the SPOT satellite.

On 10 February 1988, Belgium joined the European Space Agency's three major optional programmes at the following levels of participation:

- European launcher Ariane 5 - 6.0 per cent
- European shuttle Hermes - 5.8 per cent
- Space station Columbus - 5.0 per cent.

This decision followed the commitments undertaken during the ministerial conferences of the ESA member countries that had been held at Rome in January 1985 and at the Hague in November 1987.

On 29 September 1988, the Minister for Scientific Policy signed the intergovernmental agreement on cooperation between the European States involved in the Columbus project, Canada, Japan and the United States of Amercia.

On 21 December 1990, the Council of Ministers decided in favour of Belgian participation in the MIRAS programme, which envisages the launching of a Belgian-made atmospheric observation spectrometer on board the Russian orbital station MIR 2 in 1994.

On 21 November 1991, the Council of Ministers endorsed the updated Long-Term Plan of ESA, submitted at the Munich ministerial conference in November of that same year.

On 27 November 1992, the Council of Ministers endorsed the restructuring and further updating of the ESA Long-Term Plan in the direction of an improved balance between utilization programmes - specifically, Earth observation - and infrastructure programmes, in the implementation of which international cooperation was to be a key factor.

On 4 December 1992, the Council of Ministers decided in favour of Belgian participation in the SPICAM-S project, which is part of the payload of the Russian MARS 94 space probe, scheduled to be launched in 1994 for the exploration of the planet Mars.

C. Activities

Space activities are managed at the Scientific Policy Planning Service (SPPS) by a Space section, which is specifically responsible for Belgian representation in ESA bodies, the monitoring of the industrial activities carried out in Belgium, and negotiations with official international and foreign agencies.

Activities are currently going forward in a number of areas.

1. European Space Agency

After having joined the three optional space infrastructure programmes - Columbus, Ariane 5 and Hermes - Belgium is also participating in the ESA user programmes. These are Earth observation, communication and microgravity programmes that will make it possible to boost considerably the economic and scientific return on space activities.

The Earth observation programmes will mainly provide a basis for the development of scientific instrumentation to be carried on board polar platforms.

Through the telecommunication programmes it will be possible to develop data relay satellites and associated technology. These programmes will also permit the development of future telecommunication

satellite generations as well as the ground station technology so as to make possible the optimal use of the space infrastructure and of telecommunication satellites in general.

The aim of the microgravity programme is the development of instruments for common use by European researchers. The instruments designed for specific use by selected Belgian research specialists will be nationally financed.

The ESA (obligatory) scientific programme will be gradually strengthened.

2. SPOT

Belgian industry is associated with the programme involving remote sensing satellites of the SPOT series as well as the ground-based component of the system:

- SPOT 1, launched on 11 January 1986
- SPOT 2, identical to SPOT 1 and launched on 21 January 1990
- SPOT 3, identical to SPOT 1 and launched on 26 September 1993
- SPOT 4 and SPOT 5.

3. MIRAS

Belgium is a participant in the MIRAS programme.

The objective of this programme, following a proposal by the Institute of Space Aeronomy of Belgium (IASB), is to place in orbit an infrared Earth observation spectrometer on board the Russian orbital station MIR 2, which is to be launched in 1994 and will provide a means of conducting continuous global observations over a period of several years. Thanks to this instrument it will be possible to perform synoptic, homogeneous and repetitive measurements, particularly as regards the trace molecules present in the Earth's atmosphere.

This cooperative scientific undertaking stems from an agreement signed by the Russian and Belgian authorities on 9 September 1990.

4. SPICAM-S

Belgium is also participating in the SPICAM-S project: spectrometer for the investigation of the characteristics of the atmosphere of Mars.

The SPICAM-S project, which is the solar component of the international SPICAM project, is aimed at determining the composition of the Martian atmosphere through the observation of sunlight. It is covered in the agreement reached on 30 September 1987 between Belgium and the former Soviet Union.

SPICAM-S is an experimental project that has been developed in collaboration between the Institute of Space Aeronomy of Belgium (IASB), the French National Centre for Scientific Research (CNRS), the French National Centre for Space Studies (CNES) and the Institute of Space Research (IKI) of the Russian Academy of Sciences.

5. Centre for Remote Space Operations

In March 1993, the Centre for Remote Space Operations, which is located at the Royal Meteorological Institute of Belgium (IRMB), became operational.

The Centre's infrastructure and the associated data transmission network will make it possible to carry out remote scientific experiments from each of the universities and research centres having access to the network. It will also be possible to use the network to receive, in real and deferred time, the results of space experiments conducted in orbit through the communication nodal point set up at the IRMB.

6. Projects in preparation

SPOT project

The intergovernmental agreement concluded between Belgium and France paved the way for Belgian participation in the development of the satellite remote detection system (SPOT).

This project is to be expanded, in work that will involve a 50-per-cent participation by the European Community, for the purpose of monitoring natural and cultivated continental ecosystems by means of an instrument (VEGETATION) to be carried on board the SPOT 4 satellite.

The scientific and industrial communities are directly involved in the design and use of this payload.

In addition to its scientific significance, it is obvious that the development of a payload of this kind marks a considerable contribution to environmental policy, which explains why it aroused the interest of the Governments meeting at the Rio Ministerial Conference.

Mini-satellite project

The mini-satellite project involves the design of a low-orbit message-handling mini-satellite designed to meet the needs of non-governmental and humanitarian organizations.

There are three concerns that underlie the various activities that have been described:

- To ensure, for industry, a fair return on Belgium's contribution to European and foreign space programmes in the form of contracts concluded with Belgian firms.
- To permit, at the scientific level, optimal access for Belgian researchers to the most advanced equipment and to the results of experimentation in orbit.
- To profit, in terms of the immediate prospects for the use of space for industrial and commercial purposes, from the sizeable investment undertaken by the country. The aim is to ensure that Belgium is properly represented in the industrial structures that will operate in the new emerging markets.

D. Subjects of interest

The European Space Agency is developing, or pursuing the development of, programmes specifically covering the following areas and projects:

- Space science:
  - Sun-Earth relationships
  - Plants and primitive bodies of the solar system
  - X-ray astronomy
  - Sub-millimetre astronomy
- Earth observations:
  - Coastal, oceanic and glacial phenomena
  - Terrestrial solid-state physics

- Applications:
  - Agriculture
  - Silviculture
  - Hydrology
  - Geology
  - Maritime navigation
  - Fisheries
  - Petroleum activities
- Microgravity:
  - Crystallogenesis
  - Metallurgy
  - Composite materials
  - Fluid physics
  - Electrophoresis
  - Cellular biology and embryology
  - Human physiology
- Telecommunications:
  - Development of payloads and space vehicles and experiments
  - Advanced systems and technology
  - Data relay satellites (Olympus)
- Space transport:
  - Ariane 4
  - Ariane 5
  - Hermes
- Space station:
  - Columbus
- Recoverable platform:
  - Eureka.

CANADA

[Original: English]

A. History and current status of cooperation

The Canadian Space Programme has always been based on international cooperation. From the early days of ground-based scientific research to current projects, the vast majority of Canadian activities have been undertaken to some extent in cooperation with foreign partners.

1. United States of America

Historically, Canada's main partner in space activities has been the United States. For over 35 years, this has involved collaboration in all sectors of activity, such as:

- Space science research (solar terrestrial physics, astronomy, microgravity life and materials sciences, atmospheric sciences)
- Space technology development
- Human space flight (astronaut flights, contribution of a robotic manipulator - Canadarm - on the United States Shuttle)
- Earth observation (space and ground systems, commercialization of data)
- Satellite communications.

Several significant collaborative projects are now underway. For instance, Canada is a partner with the United States, several European nations, Japan and soon formally with the Russian Federation in the International Space Station project (Canada provides the Mobile Servicing System, for the assembly, maintenance and operation of the Station). The Canadian Space Agency (CSA) is also preparing for the flight in October 1995 of Major Chris A. Hadfield on the Atlantis Shuttle Orbiter, who will conduct various experiments and tests of the Canadian Space Vision System, which system will serve on the International Space Station. In addition, Canada and the United States, together with France and the former Soviet Union, are founding partners of the satellite search and rescue system, COSPAS-SARSAT.

CSA is now preparing for the launch of RADARSAT I, Canada's first Earth observation satellite, on a Delta II rocket provided by the United States. RADARSAT I will be able to see through clouds and perform observations during the night using synthetic aperture radar (SAR) technology for a variety of applications relating to environmental monitoring and resource management. MSAT, a mobile communications satellite involving close cooperation between the Canadian company Telsat Mobile Inc. and the American Mobile satellite Corporation, will also be launched in 1995. Work is progressing on the development of the measurement of pollution in the troposphere (MOPPIT), an instrument to be placed on the AM-1 platform as part of the United States Mission to Planet Earth programme. Many other projects are underway that involve close cooperation with the United States in various areas.

2. European Space Agency

For over 15 years, Canada has been a Cooperating State of the European Space Agency. The first Cooperative Agreement was signed in 1979, and it was renewed in 1984 and 1989, the latter for 10 years. It provides for close Canadian participation in some governing bodies of ESA, as well as Canadian participation in some mandatory activities and optional programmes relating to Earth observation and satellite communications, with some contributions to human spaceflight activities. Canada is the only non-European country to be such a close participant in several ESA activities. There is also close cooperation in the context of the International Space Station.

3. France

Cooperation between Canada and France has involved, for instance:

- Joint development of the Wind Imaging Interferometer, placed on the United States UARS satellite in 1991
- Both countries being founding partners in the COSPAS-SARSAT system
- Cooperation on the Interball science project led by the Russian Federation
- Joint development and launch later in the 1990s of ODIN, the space science satellite project led by Sweden
- Discussions on possible cooperation on the future RADARSAT III project
- Joint marketing of Earth observation data (involving Radarsat International Inc. and Spot Image)
- Ongoing discussions on enhanced industrial cooperation.

4. Other partners

Canada has also been very active in addressing cooperation opportunities with other partners, including the Russian Federation (several space science and microgravity research projects such as the Interball Radioastron and Spektrum-X/Gamma programmes, cooperation in the context of the SOVCANSTAR project for the manufacture and launch of several communications satellites for Russian and domestic as well as international communications; joint collaboration in the context of the International Space Station and flights to, and experiments on, the Mir space station; Sweden (cooperation on the VIKING, FREJA and ODIN science satellite projects); Germany (cooperation in the joint design of methods for the qualification of space

structures, and in microgravity research); and Japan (the Canada-Japan Space Panel regularly meets to address present and future cooperation opportunities, and there is specific cooperation on AKEBONO, Planet-B and in microgravity research).

Canada is also discussing increased cooperation opportunities for collaboration with other countries, including China, Italy, Thailand, United Kingdom of Great Britain and Northern Ireland, and several countries in Latin America. For example, Canada is cooperating with Brazil to develop tropical rainforest information management systems based on Earth observation data, and Canada also provided that country's first-generation communications satellite system.

Canada is also active in the context of the Committee on the Peaceful Uses of Outer Space of the United Nations, and in other international forums, such as the Space Agency Forum, Intelsat, Inmarsat, and others.

B. Opportunities for greater international cooperation

In June 1994, the Canadian Government approved the new Canadian Space Programme. This new programme calls for investments in the following sectors:

- Earth observation (completion of RADARSAT I, initiation of RADARSAT II, advanced radar technological development, ground segment upgrades, applications development and technology transfer)
- Satellite communications (launch of MSAT, a programme for advanced satellite communications development and a programme for development of technologies for mobile communications)
- Space science (activities in solar-terrestrial physics, atmospheric sciences, astronomy and microgravity life and materials sciences, a space science enhancement programme and the possibility of two small satellites for science missions)
- Space technology (ongoing in-house and contracting-out development, a new Strategic Space Technology Development Programme and contributions to new ESA programmes)
- Flights for Canadian astronauts (opportunities on the United States Shuttle and preparation of related science experiments)
- A new Space Awareness Programme, to encourage Canadian youth to undertake careers in science and technology.

Also in June 1994, the Government announced that, further to the successful conclusion of discussions with NASA, Canada would remain a full partner in the context of the International Space Station, albeit at a reduced cost.

The new Canadian Space Programme also mentions that space activities are of strategic importance to Canada's transition to a knowledge-based economy and identifies CSA as the lead coordinator for all policies and programmes of the Canadian Government in civil space-related research, science and technology industrial development and international cooperation.

Cooperation is essential to the implementation of the Canadian Space Programme, as it promotes the sharing of costs and risk in the realization of programmes and activities. The time for cooperation has never been so good, with new opportunities resulting from such major events as the end of the cold war and the increased realization in the world as to the importance of space technologies, systems and science for sustainable development. Clearly, issues affecting the common welfare call for common solutions, and international space cooperation therefore becomes a chosen instrument.

In this context, and also because the majority of Canadian space activities have always been undertaken in collaboration with foreign partners, it is expected that significant opportunities for enhanced international cooperation will arise in the future, especially in the context of the new Canadian space programme. These

cooperation possibilities are expected to be found in most sectors identified above in the description of the programme and, more specifically, space science research communications, space technological development (including new ESA opportunities), radar technology and systems development, the application of RADARSAT data.

Several of these cooperation opportunities could be very helpful in furthering the process of sustainable development, where possible. In particular, Canada (mainly through the efforts of the Canada Centre for Remote Sensing (CARS) and the Canadian International Development Agency) has been working closely with developing countries in all regions in addressing the potential uses of RADARSAT data for a variety of applications, such as geology and geomorphology, identification and monitoring of primary forests, hydrology, soil erosion and disasters. Technical training and data analysis workshops have been held and assistance in the provision of relevant equipment has been provided, and other such opportunities could be considered.

Further, there could be interesting opportunities in the use of satellite telecommunications services for tele-education and tele-medicine, as well as in the field of global change research. In the latter case, such cooperation could be facilitated on the American continent through the new Inter-American Institute for Global Change Research.

The Canadian Space Agency and its partners in the implementation of the Canadian Space Programme would welcome any suggestions from existing or potential new partners regarding the possibilities for increased cooperation.

INDIA

[Original: English]

A very significant milestone in the Indian Space Programme was achieved on 15 October 1994 with the successful launch of the Polar Satellite Launch Vehicle (PSLV), from the Shriharikota Range (SHAR) at 1035 hours Indian Standard Time (IST). In the second developmental launch (PSLV-D2), the 804 kg Indian Remote Sensing Satellite (IRS-P2) was successfully placed in a near polar Sun-synchronous orbit of about 825 km altitude and 98.6 degree inclination. Shortly after the separation from the launch vehicle, the satellite solar panels were deployed automatically by an onboard sequencer and the event was monitored by the Mauritius station of the ISRO Telemetry, Tracking and Command Network (ISTRAC). Preliminary data from IRS-P2 indicates normal performance of the satellite.

PSLV-D2 took off with the ignition of the core first stage and two of the six strap-on motors. 30.5 seconds later the remaining four strap-on motors were ignited. The first set of strap-on motors separated as planned at 73.4 seconds after lift-off and the second set of strap-on motors separated at 90.4 seconds after lift off. First stage separation and second stage ignition occurred 111 seconds after launch. The heatshield was jettisoned at 154 seconds at an altitude of 117 km after the launch vehicle had cleared the dense atmosphere. The second stage separation and the third stage ignition occurred at 261 seconds. Third stage separation occurred 380 seconds after lift-off at an altitude of 421 km. The last stage ignited after a long coasting at 591.4 seconds. The fourth stage cut-off occurred at 988.2 seconds and the IRS-P2 satellite was injected into orbit 1,012 seconds after launch at an altitude of approximately 820 km.

The closed-loop guidance system became operational at about 157 seconds after lift-off as planned and guided the vehicle till satellite injection. The spacecraft was placed in a precise orbit in three-axis stabilized mode and guided injection.

Modifications based on flight data analysis of the first PSLV launch, on 20 September 1993, were incorporated into the second vehicle. The first launch flight validated all the individual systems on the vehicle, even though the vehicle was unable to place its payload, the IRS-1E satellite, into the intended orbit due to a software implementation error.

PSLV is technologically the most challenging endeavour undertaken by ISRO to date. With a launch weight of 283 tonnes, PSLV measures 44 metres in height. The first stage of PSLV, rated as the third largest solid-fuel booster in the world, carries 129 tonnes of solid propellant and measures 2.8 metres in diameter. The motor casing is made of indigenously produced maraging steel. The booster develops a maximum thrust of 4,500 kN. The first stage thrust is augmented by six strap-on motors. Each of these solid propellant strap-on motors, using locally produced hydroxyl terminated poly butadiene (HTPB) fuel and ammonium perchlorate oxidiser, produces 662 kN of thrust.

The second stage employs the indigenously manufactured Vikas engine and carries 37.5 tonnes of unsymmetrical di-methyl hydrazine (UDMH) as fuel and nitrogen tetroxide (N_2O_4) as oxidiser. It generates a maximum thrust of approximately 725 kN.

The third stage uses a solid propellant motor producing a maximum thrust of 340 kN and has a propellant loading of 7.2 tonnes. Its motor case is made of polyaramide (Kevlar) fibre. As in the first stage, this motor is powered by HTPB-based propellant.

The fourth and terminal stage of the PSLV has a twin engine configuration using liquid propellant with a propellant loading of 2 tonnes (Mono-methyl hydrazine + N_2O_4). Each of these engines generates a maximum thrust of 7.4 kN.

The metallic bulbous heat-shield of the PSLV, 3.2 metres in diameter, is of iso-rigid construction and protects the spacecraft during the atmospheric regime of the flight.

The control system of the PSLV includes:

- First stage: Secondary Injection Thrust Vector Control (SITVC) for pitch and yaw, reaction control thrusters for roll and SITVC in two strap-on motors for roll and roll augmentation
- Second stage: Engine gimbal for pitch and yaw, and hot gas reaction control for roll
- Third stage: Flex nozzle for pitch and yaw and PS4 reaction control system (RCS) for roll
- Fourth stage: Engine gimbal for pitch, yaw and roll, and on-off RCS for control during the coast phase.

The inertial navigation system (INS) for PSLV is a strap-down version with the guidance system housed in the equipment bay. INS guides the vehicle till orbital-injection of the spacecraft.

The main on-board instrumentation packages used for telemetry, tracking and command are PCM/S-band telemetry systems, S-band range and range rate transponders and C-band transponders, in addition to a host of power and signal conditioning packages.

PSLV employs a large number of stage auxiliary systems for stage separation, heat-shield separation and jettisoning etc.

The Polar Satellite Launch Vehicle is the first ISRO Launch Vehicle to use liquid engines for primary propulsion. Other important technologies incorporated in PSLV are: 2.8 metre diameter solid booster, flex nozzle and engine gimbal control systems, and strap-down inertial navigation systems. Some of these technologies are derived from past projects such as SLV-3 and the ASLV programmes.

To design, develop and demonstrate these new technologies, ISRO augmented the existing management infrastructure in some areas and created new ones in others - both within and outside ISRO. Some of the major facilities established for PSLV include liquid stage test facilities at Mahendragiri in Tamilnadu; large solid booster preparation and test facilities; new launch complex including the giant mobile service tower at Sriharikota; a new complex at Valiamala near Thiruvananthapuram where facilities have been established for integration and checkout, large scale structural testing (such as ground resonance testing) and for testing separation and jettisoning systems, control component development facilities etc.

With the Vikram Sarabhai Space Centre in Thiruvananthapuram acting as the lead centre, major responsibilities for design and development of PSLV were shared by the Liquid Propulsion Systems Centre, also headquartered in Thiruvananthapuram, and the SHAR Centre in Sriharikota. The ISRO Inertial Systems Unit, Thiruvananthapuram, developed the navigation systems for the launch vehicle. The ISRO Telemetry, Tracking and Command Network (ISTRAC) was responsible for the telemetry and tracking support.

Well over 150 local industries, both in the public and private sector, were involved in the fabrication of a variety of hardware such as light alloy structures for interstages, motor casings, electronic packages, heat-shields and precision coherent radars. Even in the field of chemicals and materials, the industries played a vital role. For example, the maraging steel and HTPB resin are produced by the industries. Prime examples of industries in the public sector which made major contributions to PSLV are Hindustan Aeronautics Ltd., Biharat Electronics and Mishra Dhatu Nigam.

The Indian Remote Sensing Satellite, developed by the ISRO Satellite Centre, Bangalore, is the third Indian remote sensing satellite. IRS-P2 weighs 870 kg and its two solar panels generate 510 W of power. The primary imaging system is the Linear Imaging Self Scanner (LISS-II) camera, similar to LISS-II flown on board IRS-1A and 1B. The camera operates in a push-broom scanning mode using Charge Couple Diode (CCD) arrays. It has a spatial resolution of 32 m across track and 37 m along track. The swath is 131 km. LISS-II operates in four spectral bands in the visible and near infra-red regions. The payload was developed by the Space Applications Centre.

IRS-P2 is being monitored and controlled by a network of ISTRAC stations at Bangalore, Lucknow and Mauritius with the Spacecraft Control Centre at Bangalore. Telemetry, Tracking and Command (TTC) support is also being provided by the station at Bearslake near Moscow. During the initial phases of the mission TTC was provided by stations at SHAR, Thiruvananthapuram and Weilheim, Germany. The IRS-P2 data reception and processing is carried out by the National Remote Sensing Agency, Hyderabad.

The success of PSLV-D2 marks an important milestone in India's effort to achieve indigenous capability in launch vehicle technology.

JAPAN

[Original: English]

A. Space science

1. Lunar and planetary exploration

PLANET-A Project: Halley's Comet Exploration

Japan's Institute of Space and Astronautical Science (ISAS) launched an interplanetary spacecraft, Suisei, into heliocentric orbit in 1985 to explore Halley's Comet, which reappeared in 1985/86 after 76 years. ESA,

NASA and the Russian Federation also sent spacecraft to the comet in an international collaborative project. The Lyman-α imager (UVI) on board Suisei observed the activity of hydrogen in the coma of the comet and found the rotational period of the nucleus. Suisei crossed the bow shock generated by the interaction between the solar wind and Halley's Comet. The phenomena near the shock wave were studied by an on-board plasma analyser.

LUNAR-A Project: Moon Penetrator Mission

ISAS plans to send a spacecraft called LUNAR-A to the Moon in 1997. It will be the second flight of the M-V vehicle which is under development by ISAS. LUNAR-A will drop three penetrators onto the Moon. The penetrators are supposed to penetrate the lunar surface and form a network which will explore the internal structure of the Moon using on board seismometers and heat-flow meters.

PLANET-B Project: Mars Atmosphere/Plasma Mission

PLANET-B is the first Japanese Mars mission and is scheduled for launch in 1998 by the M-V-3 vehicle. It will be injected into orbit around Mars and will study the Martian upper atmosphere, especially its interaction with the solar wind.

Projects under discussion

Among the lunar/planetary missions under discussion by ISAS are:

- Mars Rover Mission
- Venus Aerocapture/Balloon Mission
- Comet Coma Sample Return Mission.

2. Astrophysics

ASTRO-series Project: Satellites for Astronomical Observations

The fourth X-ray astronomy satellite ASTRO-D (ASCA) following Hakucho, Tenma and Ginga was launched in February 1993. ASCA is the acronym for Advanced Satellite for Cosmology and Astrophysics. It is a high-throughput imaging and spectroscopic X-ray observatory. About 40 days after the launch of ASCA, a supernova SN1993J appeared in the nearby galaxy M81. ASCA detected X-rays from this supernova approximately a week after the discovery. The satellite is equipped with four X-ray telescopes and a suite of focalplane instruments (CCD cameras and imaging gas scintillation proportional counters). These instruments are achieving outstanding discoveries under Japan/United States collaboration.

A Japan/United States collaborative solar maximum observation is being carried out using the satellite Yohkoh (SOLAR-A) launched in August 1991. It is obtaining an enormous number of X-ray images of the Sun in its period of maximum activity.

Another X-ray astronomy satellite (ASTRO-E) and an infrared astronomy satellite are now being studied for launch in the late 1990s. In infrared astronomy, observations from stratospheric balloons and sounding rockets have been conducted. Observations from the Space Flyer Unit (SFU) are also scheduled.

VLBI Space Observatory Programme: Satellite for Space VLBI

A satellite for very long baseline interferometry (VLBI) called MUSES-B will be launched by the Institute in 1996. It will be the first flight of the M-V vehicle.

3. Solar terrestrial science

EXOS-series Project: Satellites for Observing Earth's Upper Atmosphere

ISAS launched three EXOS-series satellites before EXOS-D. EXOS-A (Kyokko) was a polar orbiting satellite, and conducted auroral observations including the world's first imagery of global aurora in ultraviolet. EXOS-B (Jikiken) observed the plasmaspheric structure and the auroral kilometric radiation. These satellites were dedicated to the International Magnetospheric Study (IMS). EXOS-C (Ohzora) was launched in 1984. It was dedicated to the Middle Atmosphere Programme (MAO) and measured ozone and aerosols. It also monitored plasma and energetic charged particles.

EXOS-D (Akebono) was launched in 1989. It is polar orbiting and studies the acceleration mechanism of auroral particles by making extensive measurements in the 300 km to approximately 8,000 km range. One of the major experimental instruments of this mission, the suprathermal energy particle mass spectrometer, was prepared in collaboration with Canada.

GEOTAIL mission

An extended tail of magnetic fields is formed on the night-side of the Earth by the interaction of the geomagnetic field with the solar wind. The objective of the GEOTAIL mission, which was launched in 1992, is to study the structure and dynamics of the Earth's magnetotail up to a distance of 1.4×10^6 km, which is 220 times the Earth's radius. Of particular interest are detailed observations of fields and particles to clarify the particle acceleration by the reconnection mechanism. GEOTAIL is a collaborative programme with NASA, and it was launched by a NASA Delta II launch vehicle.

International Solar Terrestrial Science Project

A network of satellites will be formed by more than 30 spacecraft of four agencies (ESA, Intercosmos, ISAS and NASA) to advance the understanding of solar terrestrial phenomena. The overall programme will be coordinated by the Inter-Agency Consultative Group for Space Science (IACG) composed of the space agencies mentioned above.

Key observational data of these spacecraft will be summarily processed and distributed to participating organizations. Some ISAS spacecraft, such as GEOTAIL, Akebono, Sakigake and Yohkoh, are expected to play important roles in this project.

B. Communications and broadcasting technology

1. Communications

The first Japanese satellite communications satellite, Sakura, was launched with a United States Delta rocket in December 1977. After many results were obtained from various kinds of communications experiments, the satellite was deorbited from the geostationary orbit in November 1985.

CS-2 satellites (Sakura-2a and Sakura-2b) were launched with N-II rockets in February and August 1983. Throughout the planned mission period of five years, these satellites proved very useful in providing communications to isolated islands and providing means for emergency communications.

To deal with increasing and diversifying communications demands and to accelerate accumulation of technological and development of communication satellites, CS-3 satellites (Sakura-3a and Sakura-3b) were developed by NASDA and launched by H-I rockets in February and September 1988. Each of the CS-3

satellites, which weigh about 550 kg, is in geostationary orbit and is equipped with 12 transponders and has the capacity of about 6,000 two-way communication circuits. Their design life is approximately seven years.

After checking the functions and performances of both satellites, NASDA handed over the Sakura-3a and Sakura-3b to the Telecommunications Satellite Corporation of Japan (TSCJ). (TSCJ was renamed the Telecommunication Advancement Organization in October 1992.) Under the control of TAO, Sakura-3a and Sakura-3b are in good condition and now provide various kinds of communication services for the Government, NTT, other public organizations and private enterprises aiming at in-house communications.

In the private sector, two satellite communication enterprises purchased communication satellites from the United States and began providing commercial satellite networks in April 1989. The N-STAR communications satellite (N-STARa and N-STARb) being procured from the United States by NTT are scheduled to be launched by Ariane rockets in 1995 to maintain the satellite communication services now being provided by CS-3.

2. Broadcasting

Japan's first broadcasting satellite, BS Yuri, was launched in April 1978 and conducted a series of radiowave transmitting and receiving tests and satellite operation technology experiments for 3 years and 10 months.

The results from the experiment proved to be excellent, and the actual utilization phase was begun. Broadcasting satellites BS-2 (Yuri-2a and -2b) were launched with N-II rockets in January 1984 and February 1986. Utilizing these facilities, NHK has been conducting two-channel, colour television broadcasting since 1986.

To continue this kind of service, to meet new broadcasting needs and to develop more advanced technology, NASDA has developed two larger BS-3 broadcasting satellites (BS-3a and -3b). BS-3 has the ability of three-channel colour television broadcasting services and a useful life of seven years.

BS-3a was launched by the H-II rocket in August 1990. After on-orbit experiments were completed, the satellite has been tracked and controlled by TAO. Using this satellite, NHK has continued to provide two-channel colour television broadcasting services of BS-2 since November 1990. Two private broadcasting enterprises have also started to provide broadcasting services. One is Japan Satellite Broadcasting Inc. (JSB) that provides one-channel television broadcasting services. The other is Satellite Digital Audio Broadcasting Co. Ltd. (SDAB) that provides digital audio broadcasting services using the same transponder that JSB uses.

BS-3b was launched by the H-I rocket in August 1991. One BS-3b transponder is being launched for experimental high definition television (HDTV) satellite broadcasting by the Hi-Vision Promotion Association.

In order to augment the reliability of the satellite broadcasting system, a back-up broadcasting system (BS-3N) is being procured from the United States by NHK and JSB. This satellite is scheduled for launch by an Ariane launcher. Furthermore, BSAT broadcasting satellites (BSAT-1a and -1b) are now being procured by NHK and JSB etc. and are scheduled to be launched in 1997 and 1998 to maintain the satellite broadcasting service now being provided by BS-3.

3. Satellite for Communication and Broadcasting Technology

The objectives of the research and development of the Satellite for Communication and Broadcasting Technology (COMETS) are to develop and experimentally demonstrate new technology in the area of

advanced satellite mobile communications technology, intersatellite communications technology and the advanced satellite broadcasting technology.

The satellite weighs about 2,200 kg in orbit at the beginning of its life and the design lifetime is three years. The satellite is scheduled to be launched by a H-II rocket in the winter of 1997 into a 112 degree east (tentative) geostationary orbit.

Advanced satellite mobile communicauons technology

An advanced system of L- and S-band satellite mobile communications system will be developed to provide Ka and millimetre waveband satellite mobile communications system with Demodulators/Modulators on-board satellite switches.

Optical Inter-Orbit Communications Engineering Test Satellite

The Optical Inter-Orbit Communications Engineering Test Satellite (OICETS) will be launched into low Earth orbit (LEO) aboard a J-I rocket to conduct, under the international cooperation with ESA, in-orbit demonstrations of pointing, acquisition and tracking technology, and other key technology elements for optical inter-orbit communications, which will be important for future space activities. The ongoing demonstration will be conducted with the ARTEMIS geostationary satellite of ESA.

Intersatellite Communications Technology

To provide an uninterrupted large capacity data communications link to the Advanced Earth Observation Satellite (ADEOS) and Japanese Experimental Module (JEM), intersatellite communications technology will be developed.

Advanced satellite broadcasting technology

For future satellite broadcasting services, such as HDTV, Integrated Service Digital Broadcasting (ISDB) and provincial satellite broadcasting, a 21 GHz band satellite broadcasting system with a multibeam will be developed.

C. Earth observation

1. Geostationary meteorological satellite

Japan's geostationary meteorological satellite (GMS) Himawari observes the weather system from space as on the World Weather Watch (WWW) programmes of the World Meteorological Organization.

GMS covers an area with a radius of 6,000 km (about 25 per cent of the Earth's surface area), 36,000 km above the Earth, at 140 degrees east longitude.

Japan's first GMS was launched by a United States launch vehicle in 1977. The GMS-2 was launched in 1981 and GMS-3 was launched in 1984 by Japan's H-I rocket. The present satellite, GMS-4, which was launched in 1989 by Japan's H-I, is operated by the Japan Meteorological Agency.

The main function of GMS is the meteorological observation of cloud distribution, sea-surface temperature and cloud-top temperature using the Visible and Infrared Spin Scan Radiometer (VISSR).

The resolution of the visible sensor of VISSR is 1.25 km and that of the infrared sensor 5 km. These meteorological observation data are distributed to the Medium-Scale Data Utilization Stations (MDUS) in the countries of Asia and the Pacific including Japan, and to the Small-Scale Data Utilization Stations (SDUS) through the GMS. The data distributed to the former are the high resolution data called stretched VISSR and the data distributed to the latter are low resolution data called Weather Facsimile (WEFAX).

VISSR meteorological observation data are useful for determining changes and the scale of typhoons, low pressure and warm/cold fronts in real-time, and thus improves weather forecasting.

2. Geostationary Meteorological Satellite-5

The Geostationary Meteorological Satellite-5 (GMS-5) is scheduled to be launched in 1995 as a successor to the GMS-4 and is being developed satisfactorily.

The abilities of the VISSR of the GMS-5 will be an improvement on the system on-board GMS-4. In addition to the visible channel and the IR channel, a water vapour channel will be introduced. Futhermore, the IR window will be divided into two channels. The former will provide information on water vapour distribution in the atmosphere and the latter will give a more accurate sea surface temperature extraction. These are expected to improve both short- and long-range weather forecasting services.

Futhermore, the GMS-5 will be newly equipped with a SAR for the relay of distress signals on an experimental basis.

3. Marine observation satellite

MOS-1, Japan's first remote sensing satellite (named "Momo" meaning peach tree) is part of the development of a satellite-based Earth observation system designed for effective utilization of the resources of the Earth and the conservation of the environment. The satellite's specific objectives are to observe marine phenomena involving colour and temperature on ocean surfaces, and to establish the technology common to satellites for Earth observation. This satellite was launched in February 1987.

MOS-1 is a box type, three-axis stabilized satellite with a single-wing, partial solar panel. Its orbit is Sun-synchronous, subrecurrent at an altitude of approximately 909 km at an inclination of about 99 degrees.

MOS-1 mission equipment includes a multi-spectral electronic self-scanning radiometer (MESSR), a visible and thermal infrared radiometer (VTIR), a microwave scanning radiometer (MSR) and a data collection system transponder (DCST). MESSR observes the sea and ground surface colour over an area with width of about 100 km using four bands of visible and near-infrared rays. Its ground resolution is about 50 m. VTIR monitors sea surface temperature and clouds over an area with a width of 1,500 km through one band of visible rays and three bands of thermal infrared. Ground resolution is about 900 m (visible) and 2,700 m (thermal IR). MSR observes vapour, ice and snow in the atmosphere with a width of 320 km, by using two-frequency microwaves. Its ground resolution is about 23 km and 32 km. DCST transmits the information obtained from observation platforms to the ground through MOS-1.

MOS-1 began regular operation in November 1987. Its image data is received not only at the NASDA Earth Observation Centre but also at Tokai University, ESA, Showa Base and facilities in Australia, Canada and Thailand. To confirm the usefulness of the image data transmitted by MOS-1, NASDA developed the MOS-1 Verification Programme (MVP) with cooperation from national and international research organizations.

MOS-1b, with the same specifications as MOS-1, was launched in February 1990 as the successor to MOS-1. After completing its initial test and operational phase MOS-1b entered into regular operations.

4. Japan's Earth Resource Satellite

Japan's Earth Resource Satellite (JERS-1) is an advanced Earth observation satellite which was launched in February 1992, International Space Year. The satellite carries as mission instruments an L-band synthetic aperture radar and optical sensors (OPS). The OPS feature short wavelength infrared spectral bands and a stereoscopic imaging band. The satellite is unique, with its combination of mission instruments and its global coverage capability with the mission data recorder. The satellite conducts a variety of observations not only for resource exploitation but also for land survey; agriculture, forestry and fisheries; sea ice monitoring; environmental monitoring; disaster prevention; coastal monitoring etc.

The satellite was developed as a joint development programme between STA/NASDA and MITI. STA/NASDA is responsible for developing the satellite bus, while MITI for the mission instruments. The satellite bus provides a stable platform with a high precision attitude control system, large power supply and thermal control capabilities for accommodating high-power mission instruments. Included in the satellite bus design are Japan's first use of strap-down, digital zero-momentum three-axis attitude control systems; lightweight structure; active thermal control system incorporating thermal louvres heat pipes; and the use of the satellite data bus (SDB).

The satellite was launched into a Sun-synchronous orbit at about 570 km altitude, by a two-stage H-I, from the Tanegashima Space Centre. The satellite data is received by the Earth Observation Centre in Hatoyama, Saitama Prefecture and several foreign ground stations around the world, and is made available on a public, non-discriminatory basis.

5. Advanced Earth Observation Satellite

The Advanced Earth Observation Satellite (ADEOS) will continue the Earth observation tests of MOS-1/1b and JERS-1. The main objectives of ADEOS are:

- To develop advanced Earth observation sensors
- To develop a modular satellite, as the key technology of the future platform
- To conduct experiments on Earth observation data relays, using data relay satellites to form a global observation network
- To contribute to domestic and international cooperation, by carrying announcement of opportunity (AO) sensors developed by domestic and/or foreign organizations.

ADEOS will carry two core sensors, the Ocean Colour and Temperature Scanner (OCTS) and the Advanced Visible and Near Infrared Radiometer (AVNIR). The following six A sensors are also installed on ADEOS:

- NASA scatterometer (NSCAT) by NASA JPL
- Total ozone mapping spectrometer (TOMS) by NASA GSFC
- Polarization and directionality of the Earth's reflectances (POLDER) by CNES
- Interferometric monitoring of greenhouse gases (IMG) by MITI of Japan
- Improved limb atmospheric spectrometer (ILAS) by the Environmental Agency of Japan
- Retroreflector in space (RIS) by the Environment Agency of Japan.

Inter Orbit Link (IOL) with ETS-VI and COMETS is another important mission of ADEOS.

ADEOS will be launched from Tanegashima in early 1996 by an H-II launch vehicle.

6. Tropical Rainfall Measuring Mission

The Tropical Rainfall Measuring Mission (TRMM) programme is now being conducted jointly by Japan and the United States to measure tropical rainfall. Over two thirds of the global rainfall is observed in tropical areas. Rainfall in these areas, therefore, is one of the main sources of global climate changes. TRMM will be the first mission which bears a precipitation radar, monitoring tropical rainforest from space.

The precipitation radar onboard TRMM will be provided by NASDA, based on studies which have been carried out by the Communications Research Laboratory (CRL), which has implemented collaborative activities with NASA through precipitation experiments from aircraft. NASA will provide the other sensors and the spacecraft for TRMM.

Results of this joint programme are expected to contribute to various scientific research, such as to the understanding of the mechanism of global climate change.

TRMM will be launched in mid 1997 on the H-II vehicle.

7. Advanced Earth observation satellite-II

The advanced Earth observation satellite-II (ADEOS-II), which is the successor to ADEOS, will be launched by an H-II launch vehicle around the year 1999. The objectives of ADEOS-II are to observe global environmental changes; to contribute to international scientific programmes, such as the International Geosphere-Biosphere Programme (IGBP); and to follow the ADEOS mission. The satellite is a modular type with a flexible solar array paddle. ADEOS-II will have two core sensors, developed by NASDA: Advanced Microwave Scanning Radiometer (AMSR) and Global Imager (GLI).

AMSR is a microwave radiometer with six channels, from 6.6 GHz to 89 GHz. Its observation targets are precipitation, cloud water, water vapour, sea surface temperature, ice distribution etc., all of which are concerned with water mutation. The physical values associated with them are observed with high accuracy during the night and the day.

GLI is an advanced type of the Ocean Colour and Temperature Sensor (OCTS) carried on ADEOS. GLI is developed as a multi-purpose observing spectrometer, which has more spectral bands and narrower spectral bandwidths than OCTS. This is to satisfy various mission requirements, not only in terms of the ocean, but also for vegetation and atmosphere.

In addition, there are several sensors on ADEOS-II from other agencies. The final configuration of the sensor suite will be defined in the near future.

D. Development of an engineering test satellite

The objective of developing an engineering test satellite (ETS) is to establish the basic technology for practical utilization satellites (for Earth observation, broadcasting, communications etc.), which require high-level technologies and cultivate Japan's own technology.

Using four ETSs ranging from ETS-1 "Kiku" (chrysanthemum) launched in 1975, to ETS-III, Kiku-4, launched in 1982 (all ETS were launched by N rockets), various kinds of engineering tests and operational exercises were conducted with significant achievements. These included measuring satellite environments during launch, acquiring the technology for launching geostationary satellites and tracking control technology,

confirming three-axis attitude control functions for raising development potential of the technology common to artificial satellites that require much electric power, confirming the solar battery paddle deployment functions, confirming active-type heat control functions and performing tests for ion engines and other equipment for installation under cosmic environments.

In August 1987, ETS-V, Kiku-5 was launched with a three-stage, H-I launch vehicle.

ETS-V is the first 550 kg-class, three-axis geostationary satellite developed in Japan. It is currently used for confirming performance of the experimental H-I launch vehicle, establishing basic technology for the three-axis geostationary satellite bus, confirming performance of the apogee motor, flight confirmation of new technology to prepare for the future and the aeronautical and maritime experiments for the above-ocean control of aircraft in the Pacific region, communications with ships, navigational guidance and rescue search using aeronautical maritime experimental transponders (AMEX). Mobile satellite communication experiments are being conducted by several other organizations.

ETS-VI was launched by an H-II launch vehicle in August 1994. Its injection into geostationary orbit failed due to trouble with the apogee motor. ETS-VI is currently in an elliptic orbit. The satellite bus and telecommunications experiment on board are functioning normally.

ETS-VI is a 2-tonne class satellite, with a bi-propellant apogee engine. It has an ion engine for controlling the north-south orbit; a high-precision attitude control system; a light structural body; a light solar battery paddle; and a high-heat-prevention, heat-control system in the satellite bus part. The purpose of ETS-VI was to establish the H-II vehicles' abilities, test the satellite attitude control system and its communications equipment.

ETS-VII is planned to be dual-launched with the Tropical Rainfall Measuring Mission (TRMM) from Tanegashima Space Centre in the summer of 1997.

The purpose of ETS-VII is to acquire the basic technologies of rendezvous-docking and space robotics that are essential to future space activities. ETS-VII consists of a chaser satellite and a target satellite. After launching, the ETS-VII detaches the target satellite in orbit, and then the chaser satellite conducts rendezvous-docking experiments with the target satellite. It will also conduct space robotics experiments by using a robotic arm installed onne the chaser satellite.

E. Space transportation system

1. H-I launch vehicle

The H-I is a three-stage rocket capable of launching a geostationary satellite with a weight of approximately 550 kg. The first stage rocket and solid fuel auxiliary rockets are the same employed for the N-II launch vehicle. The second stage is a high-performance liquid fuel rocket adopting liquid oxygen (LOX) and liquid hydrogen (LH) as its propellant. The third stage consists of a large solid fuel rocket developed with Japan's own technology. The inertial guidance system was developed in Japan.

The focal point of the H-I launch vehicle development is the LE-5 engine adopted for the second stage. This is a high-performance engine with a thrust of 10.5 tonnes. Using LH and LOX as its propellant, it features re-ignition capability. The solid-fuel third stage employs polybutadiene composite propellant and high strength titanium alloy for the motorcase and nozzle, resulting in a light motor with excellent performance. The inertial guidance system of the stable platform type is adopted to provide rocket guidance, titude control and sequence control. A total of nine H-I launch vehicles were launched (including two test flights).

2. H-II launch vehicle

The H-II launch vehicle is Japan's main space transportation system in the 1990s and meets the demand for large satellite launches maintaining a high degree of reliability. It is a two-stage vehicle, augmented by a pair of solid rocket boosters (SRB). It is 4 m in diameter and 50 m in height with a lift-off weight of 260 tonnes. The H-II launch vehicle is capable of launching a 2-tonne class satellite into geostationary orbit and a payload of about 10 tonnes into a space station orbit. It will be able to send a spacecraft of about 2 tonnes to Venus or Mars.

The first stage is powered by the LE-7, a staged-combustion cycle LH/LOX engine, which delivers 110 tonnes thrust in vacuum.

In order to supplement the thrust of the first stage, two SRBs with a thrust of 160 tonnes are installed. The SRBs have the thrust direction control function controlled through a movable nozzle.

The second stage uses the LE-5a engine, an improved LE-5 engine of the H-I. The standard payload fairing measures 4.1 m in diameter and 12 m in length. Its large version produced in September 1991 measures 5 m in diameter. The construction of the new Yoshinobu launch site was finished in 1991 for H-II.

The first successful test flight took place in February 1994 and the second test flight succeeded in launching the ETS-VI into a transfer orbit in August 1994. The capability and characteristics of the H-II launch vehicle were verified through these flights. The third test flight will be used to launch the GMS-5 and the SFU at the same time in 1995. The use of the H-II launch vehicles for launching various other satellites is also being considered.

3. J-1 launch vehicle

NASDA is developing the three-stage solid rocket called J-1 in cooperation with the Institute of Space and Astronautical Science to launch small satellites. The development of J-1 is intended to be completed at low cost in a short time by using the components of two existing vehicles: the NASDA solid rocket booster (SRB) of the H-II and the upper stage of the M-3II of ISAS. J-I is intended to be a time-saving launch system with minimum operation time at the launch site. J-I uses the Osaki launch facilities in the Tanegashima Space Centre, which was equipped for the H-I launch vehicle. Test flight No. 1 is scheduled in 1995 to carry a hypersonic flight experiment (HYFLEX).

4. M (Mu) series launch vehicles

ISAS has proceeded step by step to improve the launch capability of the Mu rocket series. Through the Mu development process, Japanese space science has established its position among academic societies worldwide.

5. M-3SII

Targeting the return of Halley's Comet in 1986, ISAS began research and development of the fifth and latest generation Mu vehicle, the M-3SII, in April 1981. It utilized the first stage of its predecessor M-3S, but the second and third stage motors and strap-on boosters were newly developed to enhance the payload capability. The M-3SII-1 and -2, with an optional fourth stage, injected the first Japanese interplanetary probes, Sakigake and Suisei, in January and August 1985, towards Halley's Comet. Since then ISAS has launched five more satellites into Earth orbit using the M-3SII - Ginga in February 1987, Akebono in February 1989, Hiten in January 1990, Yohkoh in August 1991 and Asuka in February 1993.

The distinctive features of M-3SII are movable nozzles of strap-on boosters that perform roll control and digitized control systems which introduces microprocessors.

6. M-V (under development)

ISAS has started to develop the M-V type launch vehicle in order to provide a larger launch capability to meet the requirements of space science in the late 1990s and early 21st century. The M-V will be 2.5 m in diameter with a height of 30 m, and will weigh 130 tonnes in total. It will be able to launch a 2,000 kg payload into low Earth orbit or 400 kg beyond Earth's gravity. The first M-V flight is scheduled for 1996. Three spacecraft, MUSES-B for space VLBI (1996), Lunar-A for the Moon penetrator mission (1997) and Planet-B for Mars orbiter (1998), have already been approved to be launched by the M-V.

A variety of space science projects are now under discussion for use of the M-V launch vehicles in the near future. Among these are:

- X-ray Astronomy
- Comet Coma Sample Return
- Lunar/Mars Rover
- Venus Aerocapture/Balloon
- Asteroid Sample Return
- Infrared Astronomy
- Solar Physics
- Atmospheric Science.

F. Space experiments/space environment utilization

Japan's major space experiment projects include:

- First Material Processing Test (FMPT)
- International Microgravity Laboratory Projects IML-1, -2
- Space Flyer Unit (SFU)
- Japanese Experiment Module (JEM) in the Space Station Programme.

1. First Material Processing Test

The First Material Processing Test (FMPT) was a project which called for a Japanese payload specialist (PS) to take part in United States Space Shuttle/Spacelab missions, as Japan's first manned space activity. Systematic space experiments covering 34 themes - chosen from material and life science fields and suggested from various quarters - were carried out. FMPT was installed and contained in three double racks within the pressurized module. These development efforts were made mainly by NASDA, not only based on Japan's own technology, but also with extensive international cooperation.

2. International Microgravity Laboratory

IML-1

IML-1 was conducted in January 1992. More than 200 scientists from 14 countries including the United States, Canada, Japan and some European countries participated in the IML-1 project. Experiments on 42 themes, including crystal growth and cell culture, were performed for eight days in a microgravity environment using 16 experimental systems developed by the participating countries.

Japan provided two sets of experiment hardware for the IML-1. Using this hardware, experiments of crystal growth for organic superconductors, and monitoring and investigating of the biological effects of cosmic radiation in a spaceflight environment were conducted.

IML-2

The second International Microgravity Laboratory (IML-2) was launched aboard the United States Space Shuttle Columbia in July 1994. Dr. Chiaki Mukai, the first female astronaut in Japan, was aboard as the payload specialist.

Experiments on 81 themes chosen from material and life sciences fields were performed for 15 days using 19 experiment systems, six of which were made by Japan. Many of the experiments were executed successfully.

3. Space Flyer Unit

The Space Flyer Unit (SFU) is an unmanned, multipurpose, reusable, free-flying platform. It has been under development by STA (through NASDA), ISAS and MITI since 1987. The SFU mission system is scheduled to be launched by the H-II launch vehicle in mid-1995. The experiments to be carried out in the SFU mission are:

- Advanced technology experiments and space observation
- Verification of the partial model of the exposed facility in the Japanese Experiment Module, attached to the International Space Station
- Flight test of advanced industrial technologies.

G. Space station programme

1. Outline of Japanese Experiment Module

Japan decided to participate in the International Space Station Programme by developing the Japanese Experiment Module (JEM). The major objectives are to contribute to the development of space science and Earth observation in particular, directed towards full-fledged space development and utilization; to advance the use of space environments; to promote science and technology in general; and through these efforts to contribute to the global community. This requires the development of several technologies new to Japan. These include the technology supporting manned space activities, and the extension of already existing rocket and satellite technology. Japan will endeavour to attain these objectives.

It is also necessary to fully comprehend the requirements of the prospective JEM users; reflect these requirements in the design; and proceed with the development while paying attention to international uniformity concerning safety, human/machinery systems, user interfaces etc.

JEM, which is being designed based on such needs, will consist of a pressurized module, an exposure facility and an experiment logistics module. These will constitute a space laboratory which will allow experiments in various disciplines to be conducted.

JEM is designed to be attached to the core of the space station. It will depend on the space station core for such principal functions as electric power, heat dissipation, living quarters for onboard engineers, air and communications.

Pressurized module

The pressurized module will provide an environment of one atmospheric pressure. Crew members will be able to conduct microgravity experiments in a "shirt sleeves" environment. It also has a system to control JEM operation, the exposed facility and its manipulators, as well as the airlock and other equipment. The outer surface of the pressure module is covered with a bumper to guard against space debris. There are about 20 racks within. It is planned that, initially, 10 of them will be equipped with experiment payloads.

Exposed facility

Crew members will use the exposed facility to conduct material experiments, scientific Earth observation, and communications and engineering tests which should be performed in an extravehicular environment. The exposed facility is designed to be connected to the pressurized module. Experiment equipment or samples will be exchanged from the exposed section of the experiment logistic module or through the air lock from the pressurized module using the JEM manipulator.

Experiment logistics module

The exposed facility will be used to transport experiment equipment, samples, various gases and supplies. It consists of a pressurized section and an exposed section. The pressurized section is designed to be attached to the pressurized module, and to carry and store the equipment and supplies for intravehicular use. The exposed section will be attached to the exposed facility, and will be used for transporting and accommodating extravehicular experiment equipment and supplies.

2. Space station operation and utilization

The space station is expected to be operated and utilized for many years, while its functions and utilization undergo changes. In its initial stage, industrial, academic and governmental users will conduct tests mainly by means of common experiment equipment. As space experiment experience is accumulated, the users are expected to develop and utilize experiment apparatus of their own, thereby paving the way to the practical use of developed technology and industrialization. Ideas for building Japan's own space station and space plans will spring from such development.

H. Start of basic and pioneering space technology research

1. Space plane

Since 1986, NAL has been engaged in the research and development of a horizontal take-off space plane capable of flying between ground and space with a safety level comparable to that of an ordinary aircraft.

Important elemental technology research items concerning such a plane include atmospheric forces, structure, guidance control and propulsion. Another important theme is the system research, which is necessary to clarify the concept of the space plane. Research and development activities will be continued to resolve these problems.

2. Basic research on winged launch vehicles

To conduct a basic study on winged space vehicles, a multidisciplinary working group of researchers from all over the country has been organized by ISAS. The group has worked to identify six major study areas relevant to winged vehicles:

- Aero- and flight-dynamics
- Navigation, guidance and control
- Development of recovery and automated landing systems
- Scientific experiments with the test vehicle
- Microgravity experiments with the test vehicle
- Development of an advanced hydrogen rocket engine.

As a first step, a gliding test of a small-scale model was carried out in June 1986, followed by flights in October 1987. Useful data for further studies was obtained in the first two areas cited above.

In 1992, a solid propellant rocket launched a winged vehicle into the upper atmosphere from a balloon floating at a high altitude. It performed the first Japanese controlled lifting entry flight.

H-II Orbiting Plane

The H-II Orbiting Plane (HOPE) is a winged, unmanned space vehicle designed to be launched by the H-II launch vehicle. The HOPE project's objective is to recover objects from orbits and to establish the basic technology for completely reusable space transport vehicles of the future. The envisioned vehicle is planned to undergo a test flight in the 2000s.

The main concepts of HOPE at the present stage are:

- It will be mounted on and launched by the two stage H-II launch vehicle
- It will be an unmanned vehicle
- It will return to the landing grounds through a winged gliding flight
- It will land on the runway automatically
- It will allow subsequent addition of the rendezvous/docking functions for space activities.

HOPE is now being studied by NASDA and NAL in accordance with these concepts.

3. Engineering satellites of ISAS

MUSES-series project: satellites for space engineering

MUSES-A, "Hiten" was launched in January 1990 and put into a double Lunar swingby orbit. ISAS completed 11 swingby manoeuvres to master the technique which was used in GEOTAIL and will be used in future planetary missions. In addition, Hiten placed a small satellite "Hagoromo" into orbit around the Moon.

In 1992, Hiten was injected into orbit around the Moon and in April 1993 the mission ended with a hard landing on the lunar surface.

The next MUSES will be MUSES-B, which is scheduled for launch in 1996 and will be dedicated to the VLBI mission.

In late 1995, ISAS will launch a reentry capsule (EXPRESS) using the M-3SII launch vehicle in collaboration with Germany. After six days in orbit EXPRESS will be recovered on the ground in Australia after a ballistic reentry.

Orbit platform for technological experiments

The orbit platform for technological experiments is a project for conducting tests on robot technology. It will supplement manned space activities and telescience technology for utilizing data relay satellites and developing the basic technology for the platform, which will receive supplies to be assembled in orbit.

PHILIPPINES

[Original: English]

A. Philippines position on international telecommunications review of frequency coordination and planning

The Philippines considers space-based technology as one of the primary solutions to the country's telecommunications and broadcasting needs. Currently, the Philippines Government is vigorously supporting the private sector consortium in launching the country's own communication satellite.

In this connection, the Government of the Philippines would like to present its views regarding the review of the International Telecommunication Union (ITU) frequency coordination and planning framework for satellite services.

It is an accepted principle that the geostationary orbit is considered a natural resource belonging to all nations, to be used according to the requirements of individual nations.

The global telecommunications industry is undergoing massive changes. Demand for satellite communications has significantly increased due to the globalization, commercialization and privatization of communications networks, the formation of domestic and international alliances among large telecommunication companies and the development of entirely new satellite systems. In this current situation, the value of a frequency coordinated slot has become very evident.

It is therefore recognized that critical improvements in the ITU regulatory process are necessary to make it more realistic, and to be able to serve the interests of all its member countries.

The Philippines would therefore like to submit the following suggested improvements:

1. Reduce the period an orbital slot in coordination is protected. Normally this period is six years, plus a three-year extension. This has resulted in a number of applications with very general characteristics. These are often referred to as "paper satellites", or satellites that may never be put into service. These paper systems are clogging up the procedures, hence, this matter should be reviewed immediately.

2. Obligate the prospective operators to demonstrate to ITU the progress with regard to the implementation of the applied satellite network.

3. Involve the ITU regional offices in the coordination process. The ITU regional offices could be used as a venue to control the coordination process in the regions. Usually, a country needs to coordinate only with other countries in the same region. The ITU regional offices will be able to call more multilateral planning meetings between administrations in order to short circuit what is always a long and time-consuming procedure.

4. Establish a mandatory dispute resolution mechanism at ITU. The Philippines supports Singapore's proposal, which highlights inequities in the present coordination process. The paper noted that country A, which has already launched a satellite and which is served notice that country B, wishing to do likewise, needs to coordinate with it, may in practice delay coordination for an unacceptably long period of time or may set down a list of preconditions which country B must comply with before country A will agree to enter into the coordination process. That list of preconditions could be unreasonable or involve great expense to country B. Some degree of priority should therefore be given to a country that has never applied for orbital slots. The Philippines recommends that ITU establish a mechanism to resolve this matter.

5. The Philippines also supports the Australian proposal for a small group of experts to review some relevant provisions of the current radio regulations to ensure equitable access to geostationary orbit and low Earth orbit satellites. In the meantime, the Space Division of ITU could adopt an informal policy where countries which have not been assigned slot(s) and which have proven that they have genuine intentions to use the slot(s) be given priority for their applications. Tangible evidence of such intentions could be the feasibility studies undertaken, launch contracts or a memorandum of understanding.

B. Remote sensing applications in the philippines

1. Introduction

The Philippines does not have a space technology agency to look after the country's activities in research and applications of space technology in general. Instead, what exists is a National Coordinating Committee on Remote Sensing (NCCRS) which was created in September 1992 and mandated to act as the national focal point of contact for the total coordination of remote sensing activities in the country in relation to the regional and international remote sensing community. While another application of space technology, namely satellite communications, is not new to the country, activities in this field are not included in the concerns of NCCRS.

NCCRS is chaired by the Department of Science and Technology (DOST), with members from the Department of Environment and Natural Resources (DENR), the National Mapping and Resources Information Authority (NAMRIA), the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the University of Philippines (UP), the Department of National Defence (DND) and the private sector represented by the Philippine Chamber of Mines and the Philippines Institute of Environmental Planners. NCCRS meets regularly every two months to monitor various remote sensing activities in the country, and is now building up a database of remote sensing experts, projects and training programmes.

There are about 20 institutions involved in remote sensing in the Philippines. Activities of these institutions range from the application of remote sensing in weather monitoring and forecasting to natural resources monitoring, soil and water management, education, aerial photography, surveying, planning and volcanology. This paper describes the capabilities and activities of the key players in remote sensing in the Philippines.

2. Historical background

Activities in remote sensing as a space technology application began in the Philippines in the 1970s with Landsat data reception and processing, using the General Electric Image 100 system, at the Department of Environmental and Natural Resources. The information so obtained was used to monitor land use and forest cover. PAGASA also started using satellite data in the 1970s (hardcopy) for weather forecasting.

From that point in the 1970s, remote sensing activities increased and intensified, up to the present. PAGASA in the 1980s acquired a basic Geostationary Meteorological Satellite Stretched Visible Infrared Spin San Radiometer (GMS-S-VISSR) ground facility through a grant from the Japan International Cooperation Agency (JICA) That system played an important role in improving the capability of PAGASA for typhoon warning and weather forecasting.

In the 1990s, a Philippine-Australia remote sensing project was inaugurated, which covered three components, namely:

- Archiving, processing, and applications
- Education and training
- NOAA reception and processing.

Currently, NCCRS is drafting a national programme on remote sensing that will define the basic policy on the conduct of this activity by various sectors and identify main directions and thrusts in further propagating space technology applications.

3. Current activities

The current activities reported here are the major remote sensing activities in the Philippines.

National Mapping and Resource Information Authority

The National Mapping and Resource Information Authority (NAMRIA) is a government agency attached to the Department of Environment and Natural Resources (DENR). It is a merger of the former Natural Resources Management Centre (NRMC), the National Cartography Authority (NCA), the Bureau of Cost and Geodetic Survey (BCGS) and the Land Classification team of the Bureau of Forest Development (LCBFD).

Hardware and software

The first digital image processing system that NAMRIA acquired was the General Electric Image 100 system in 1977. It served the then NRMC for seven years, but it is no longer operational. There are three microBRIAN systems, one of which was acquired through the National Resource Management and Development Project (NRMDP), while the other two were acquired through the Philippines-Australia remote sensing project. MicroBRIAN systems include software for image management, image processing, image analysis and integration functions.

The NAMRIA visual image processing facilities include 10 analogue plotters, 1 orthoprojector system, 1 rectifier and 1 analytical plotter. There are 32 stereoscopes, 1 pointy transfer device and 4 measuring and control systems.

In terms of geographic information systems (GIS) facilities, NAMRIA has micro-computer-based GIS software. The first is called the comprehensive resource inventory and evaluation system (CRIES), developed at the University of Michigan. This system can handle raster as well as vector data input. The software includes digitizing, grid system data storage, analysis and creation of master files, provision of statistical summaries and dot-matrix printer map production.

Another software program which was developed by Japanese consultants is known as the Forest Management Information System (FMIS). It can handle raster data only. Software functions include data entry, analysis and plotting.

The ARC-INFO is a system capable of converting vector to raster data and handling sophisticated modelling.

RASTER, which was developed by the Swedish Space Corporation, is specifically designed for the Forestry Development Project.

The TYDAS/SPANS system is capable of data integration from multiple sources. SPANS can read, write, and analyse both vector and raster data as well as use a third data structure, quadtree, as a means of storing and overlaying thematic layers which makes the system extremely efficient. It also reduces data storage tremendously.

Projects

One of the main applications projects completed by NAMRIA is the Land Condition Mapping Project. This project was commissioned by the International Bank of Reconstruction and Development (IBRD) with funding from the Swedish Aid Agency for International Technical and Economic Cooperation (BITS). It was designed to provide useful information to the Forest, Fisheries and Agriculture Resource Management (FFARM) study conducted by the World Bank for the Philippines. The project produces 43 sets of 1:250,000 scale maps, covering 98 per cent of the Philippines. The set consists of satellite image maps, interpretation overlays and land-cover maps. The SPOT data that was used were taken between April 1987 and January 1988. These were visually analysed by scientists from the Swedish Space Corporation and NAMRIA. Ground truthing was conducted in Luzon, Visayas and Midanao and digital image analyses at 1:100,000 scale were conducted for three SPOT scenes. Twenty-seven classifications were used to describe the land conditions. Land-cover statistics were generated on a regional and provincial basis. The project took a year to complete and the output was made available in 1988.

Another major project completed by NAMRIA was the Updating of Forestry Statistics. This was a joint project of the then Natural Resources Management Centre (NRMC), the Bureau of Forest Development (BFD) and UPLB College of Forestry. The project produced forest resource condition maps covering the whole country. It made use of multi-year aerial photography and Landsat data taken in the 1980s. Maps at 1:50,000 and 1:250,000 scales were produced for areas with airphotos, while 1:250,000 scale maps were prepared for areas with Landsat data. It employs a mix of digital and visual analysis techniques. Several ground truthing activities were conducted. Provincial and map statistics were generated using the dot grid method. An attempt was made to relate the statistics to administrative records and reports received from licences and field operations. However, reconciliation of data from records and the output of the project was not possible because of discrepancies. The forest resource condition maps were later used in many map overlays and digital analysis experiments and projects. A number of publications and papers can be traced back to this project.

The Mangrove Inventory of the Philippines conducted in 1978 to 1982 produced 1:250,000 scale maps showing the location, land condition, land cover and area of the mangrove resources of the Philippines. Analysis was also conducted to estimate the changes and land use conversions that have occurred in the mangrove areas. Multilevel remote sensing with extensive aerial reconnaissance was used in the project. The results of the project became the basis for a presidential proclamation declaring selected areas for preservation of conservation and identifying areas suitable for fishponds and other uses.

NAMRIA also conducted the Ecological Studies of Major Watersheds in the Philippines with the aid of remote sensing. This project was undertaken to determine the usefulness of satellite acquired information in watershed ecological monitoring. The project aimed to identify and characterize all the major watershed areas in terms of topography, vegetation cover, size and climate. The project produced the ecological maps of the Abra River Basin and the Bicol River Basin in 1983.

Coastal zone management applications and research projects include the following:

- Detection and monitoring of water hyacinth infestation in Laguna de Bay through multi-spectral digital analysis of Landsat images
- Mapping of coastal shallow reef areas
- Mapping of fishpond areas using Landsat
- Multilevel remote sensing surveys for mangrove forest resource management
- Assessment and monitoring of coastal waters for fishery resource management
- Assessment of mangrove forest deterioration in the Zamboanga Peninsula
- Lake inventory
- Mapping of bays and coves
- Coral reef mapping and inventory
- Assessment of inland water bodies
- Effects of tidal fluctuations on the spectral pattern of Landsat coral reef imagery.

Geology applications and research projects include the following:

- Geologic and Structural Mapping of the Baguio mineral district
- Evaluation of selected earthquake-prone areas
- Environmental geology application of Landsat data
- Geostructural and quadrangle mapping
- Application of Landsat to hydrology
- Updating and revision of geologic maps of the Philippines
- Application of multilevel analysis in marine geology
- Assessment and application of remote sensing techniques to groundwater studies.

Data available at NAMRIA include 129 Landsat computer compatible tapes (CCT) and 97 transparencies of scenes taken between 1972 and 1986. An additional acquisition of five Landsat CCTs and 4 SPOT CCTs for scenes taken between 1988-1990 specifically for the Australian-funded Natural Resource Management Development Project (NRMDP). As a beneficiary of the FFARM project, NAMRIA became the recipient of the project output in terms of land cover and land-use maps, raster and SPOT maps, as well as interpretation overlays. The land cover, raster and SPOT image maps were completed at 1:100,000 and 1:400,000 scales. In addition, 380 digital CCTs were also provided. From 1991 to date, NAMRIA has acquired 10 additional Landsat thematic mapper (TM) and four marine observation satellite (MOS) data of selected sites.

PAGASA is the country's local weather bureau. In 1989, it acquired a basic geostationary meteorological satellite stretched visible infrared spin scan radiometer (GMS S-VISSR) ground facility through a grant from JICA. Since its installation, the system has played an important role in typhoon warning and weather forecasting activities of PAGASA.

GMS S-VISSR Receiving and Processing Facility is a standard NEC satellite data utilization system (NESDUS) 210 series. The system is composed of the following:

- A receiving system which is responsible for the hourly reception of S-VISSR data from the GMS-4.
- A processing computer which is tasked to process the data received every hour and is linked to a display computer.
- A picture display computer unit which can loop or animate in hourly sequence a total of 36 images stored earlier in its memory.

The GMS is operated on a 24-hour basis and is capable of receiving and processing hourly satellite data. The resolution of the GMS S-VISSR data is 5.1 kilometre. The system can produce full-disk sectorized images. Colour enhancements as well as image enlargements can also be done by the system. These types of images are very useful in severe weather monitoring and typhoon forecasting. An important feature of GMS is its capability to loop a series of 36 hourly images at a desired speed. Viewing the animated cloud imageries provide a lot of valuable information about the developments in the atmosphere especially during critical situations.

As part of the Philippines-Australia Remote Sensing Project, PAGASA acquired a reception facility for the NOAA AVHRR/TOVS data.

4. Philippines-Australia Remote Sensing Project

One of the inter-agency projects that boosted the remote sensing activities in the Philippines is the Philippines-Australia Remote Sensing Project. The project involved four agencies, namely: The Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) of the DOST which acts as the overall coordinator of the project: and NAMRIA, PAGASA and the University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UPTCAGP). The goal of this project is to improve the availability of information on economic planning, management and national productivity improvement through more extensive application of remote sensing technology. NAMRIA is in charge of the archiving, processing and applications of remote sensing technology; UPTCAGP handles the education and training component; and PAGASA takes care of the NOAA reception and processing facility.

The NAMRIA component established the NAMRIA Remote Sensing Center (NRSC), whose main responsibilities are to supply raw and processed remote sensing data and to conduct applications projects in collaboration with other agencies and the private sector. Among the projects that it has undertaken are the following:

- Coastal Resource Mapping of Critical Bays with the Fisheries Sector Program of the Department of Environment and Natural Resources (FSP-DENR)
- Intertidal Resource Mapping of San Miguel Bay, Camarines Sur and the Updating of Fishpond and Mangrove of Lingayen Gulf, Pangasinan, with the International Center for Living Aquatic Resources Management (ICLARM)
- Geostructural Mapping of the 100-hectare Property of San Miguel Properties in Barangay San Antonio, Sto. Tomas, Batangas
- Coastal Resource Mapping of Sogod Bay, with Sillimad University
- Environmental Monitoring and Assessment of Mount. Pinatubo Disaster Area.

UPTCAGP is in charge of the education and training component of the Philippines-Australia Remote Sensing Project. This component is expected to enlarge the pool of personnel with expanded analytical and interpretative skills in remote sensing. UPTCAGP now offers a Masters degree and diploma programmes in the remote sensing and geographic information system (GIS). The academic programme is supported by a research and development programme wherein graduate students can conduct their research work.

In addition to the academic programme, UPTCAGP under the Project regularly offers short courses on the remote sensing and geographic information system. Among the courses offered are:

- Introduction to remote sensing and geographic information system
- Remote sensing and GIS in forest management
- Project design and implementation
- Radar remote sensing

- Geographic information systems
- Data integration techniques
- Remote sensing and GIS for local government
- Advanced image processing.

Through the Philippines-Australia Remote Sensing Project, UPTCAGP acquired a SUN workstation, a Macintosh Quadra, 12 units of PCs, digitizers, printers and various software for GIS, image analysis, database, spreadsheet and wordprocessing.

The role of PAGASA in the project is to receive the processed NOAA/AVHRR data and through Australian assistance it was able to set up the NOAA-high resolution picture transmission (NOAA-HRPT) ground receiving facility. This system is capable of providing higher resolution data which can be used for operational meteorology and other areas of interest. This enhanced the specialized services of PAGASA on meteorology.

The NOAA-HRPT system is an integrated NOAA and Tiros Operational Vertical Sounder (TOVS) processing and archiving facility. It is designed to receive high resolution data transmitted by the NOAA polar orbiting satellites. The system includes the following components:

- Satellite tracking equipment which is responsible for the actual tracking of the NOAA satellites
- An Ingest computer which is responsible for the scheduling, data acquisition and storage, and the archiving of the NOAA HRPT data
- A processing station which formats, calibrates and performs automatic processing of AVHRR data
- A forecaster's terminal installed at the forecasting centre which is intended for use by the operational forecasters in viewing processed AVHRR and TOVS data
- A remote director's terminal which can be used as a quick-look display of the latest AVHRR images processed.

The NOAA-HRPT facility compared to GMS is considered to be more versatile. The AVHRR data obtained from the facility can be used, for instance, to get a good view of cloud developments inside a typhoon. AVHRR data can also be processed to determine the extent of drought-affected areas or monitor the amount of vegetation cover. The system is likewise capable of receiving and processing satellite soundings or TOVS data. With TOVS data, the vertical profile of the atmosphere can be viewed and studied in terms of temperature and humidity variations. Sea surface temperatures over vast oceanic areas can be generated by the TOVS and AVHRR data, which information is useful for climatological studies including the El Niño phenomenon.

5. EC-ASEAN ERS-1 project

Through the ERS-1 project, the Philippines received a set of data processing equipment consisting of a SUN workstation and peripherals as well as technical and operation manuals. The set-up is designed to process AVHRR data on tropical forests as part of the global forest monitoring. In addition, the EC approved two pilot projects that will make use of ERS-1 SAR (synthetic aperture radar) data. These are:

- Application of ERS-1 SAR Data for Environmental Degradation Assessment in the Mount Pinatubo Area and Vicinity
- Application of ERS-1 SAR Data in Flood Hazard Assessment of Fluvial and Coastal Environments.

A major portion of the EC assistance will also go to training of the personnel that will be involved in the conduct of the ERS-1 SAR application projects.

6. Other institutions

One major application of remote sensing in the Bureau of Soils and Water Management (BSWM) is the updating of the land use maps which were produced during the last 15 years by conventional means, with very minimal use of satellite imageries. Of particular interest is the updating of the nature and extent of grassland and forest areas in eruption on land use using the MOS images. Using satellite images and other information such as soil type and distribution, a GIS analysis was done to predict possible mudflow and siltation over risk areas. One aspect of the analysis is the creation of three dimensional satellite images of the different zones around Mount Pinatubo which gave a good perspective regarding lahar movement.

The Certeza Surveying and Aerophoto Systems (CSAS), a private company, has acquired an IBM-PC/AT for its GIS facility, a digitizer and plotter. The system runs on PC ARC-INFO which is capable of sophisticated GIS modelling. CSAS owns two aircrafts for aerial photography using one Wild RC-8 aerial camera and one RC-10 aerial camera. They are also the authorized local distributor of SPOT data.

7. Conclusion

From its humble beginning in the 1970s, remote sensing technology has come of age in the Philippines. Aside from being time-efficient and cost-effective, the technology has proven to be reliable and accurate in acquiring primary information for the continuous inventory and assessment of natural resources and the environment. With the growing global concern for the environment and the growing need for up-to-date information for decision makers, it is expected that more institutions, including the private sector, will go into remote sensing technology.

SAUDI ARABIA

[Original: English]

The Government of Saudi Arabia states that since 1987 the Saudi Arabian Centre for Remote Sensing has been receiving information from satellites such as the United States Landsats, the French SPOT and Japanese JERS-1. This information is then analysed to reflect space images.

THAILAND

[Original: English]

A. Satellite remote sensing in Thailand

1. Remote sensing development

Satellite remote sensing was introduced to Thailand in 1972 when NASA launched the Landsat programme. Since then remote sensing technology has developed rapidly, leading to the establishment of the Thai Ground Station for multi-satellite data reception and processing. In the applications area, remotely sensed data have been used by various sectors in surveying and mapping natural resources. It is anticipated that the satellite-derived information will form an integral part of the national information management system for national planning and development.

Thailand Remote Sensing Centre

The Thailand Remote Sensing Centre (TRSC) is the principal national remote sensing body which interacts with national and international agencies involved in remote sensing. The Centre operates a ground receiving station which currently receives and processes the high resolution Landsat thematic mapper (TM) and SPOT data as well as the NOAA high resolution picture transmission (HRPT) data for the South-East Asia region. With the support of EC, the station was upgraded and is now capable of receiving Earth Resources Satellite-1 Synthetic Aperture Radar (ERS-1 SAR) data. In addition, through cooperation with Japan's National Space Development Agency (NASDA), the MOS-1 receiving station was set up. Presently, the station can receive and process MOS-1 and Japanese Earth Resource Satellite (JERS-1) SAR data.

Consequently, the Centre has an extensive archive of satellite data and serves as a domestic as well as regional satellite data distribution centre.

Dataservices/distribution

The satellite data received within the station coverage zone by TRSC are in both digital and photographic formats. The services provided are not restricted to local users but are available to all countries around the world.

Domestic and foreign users are from the public and private sectors. However, at the national level, users are mainly governmental organizations. The total value of the satellite data products that were distributed to users in various sectors in 1993 was approximately US$ 1.07 million. The breakdown of satellite data users is illustrated in table 1.

Table 1. Percentages of satellite data products distributed in 1993
(Percentage)

Data	Government	Private Sector	International
Value	15.4	5.2	79.4
Digital (CCT)	10.3	3.2	86.5
Photographic	38.7	2.9	58.4

TRSCs activities in research and application

One of the main goals of TRSC in the area of satellite applications is the development of methodologies and demonstration of ways and means of data application. Therefore, TRSC has been involved in several research projects and programmes. These include activities that have been carried out at national and international levels, most of which are on a bilateral basis. Cooperation in research with other countries has become one of the major activities during the last decade and it appears that this trend will continue, particularly on a regional level. As the National Focal Point, the role of TRSC has been to coordinate such activities as well as to participate. These cooperative programmes include those with Australia, Canada, China, Japan and the EC. Remote sensing cooperative programmes among the ASEAN countries have recently been established under the auspices of the ASEAN Committee on Science and Technology (COST) programme, as well as through bilateral agreements. Joint research projects, technical development and human resource development are areas addressed in the cooperative programmes.

Research/application support, financial and technical support have been given to various institutions to conduct research related to satellite remote sensing and its application. This research funding has been provided annually with the objective of popularizing and promoting the use of satellite imagery. TRSC facilities, which include manual and automated image analysis systems, are also made available to most users. Consultancy is among the services provided.

Education and training facilities

Most of the universities in Thailand provide a few courses on remote sensing in their curricula. In order to promote the application of this technology and to increase the user community in the country, TRSC organizes semi-annual training courses for national scientists on principles of remote sensing and digital image analysis. Moreover, specialized training and on-the-job training is tailored to complement the ongoing activities of the requesting agency.

Future development

At present, the use of remote sensing technology for surveying and mapping as well as monitoring natural resources and the environment has been carried out mostly at the departmental level and is centred on the metropolitan area. The technology has not reached the provincial or local regions of the country. A feasibility study on decentralization of the national centre is underway with the intent of setting up sub-centres in the three major regions of Thailand, i.e. the North, the Northwest and the South. This will be carried out in collaboration with the regional universities where the sub-centres will be located. These sub-centres will therefore become nodes for data distribution and application support. The emphasis, however, will be on the latter as most universities have facilities and expertise in satellite data processing and analysis. The more important role of the regional nodes will be to provide training of personnel.

2. Remote sensing in sectorial development

Various government agencies that deal with the management of natural resources, such as the Land Development Department, the Royal Forest Department, the Office for Agricultural Economics, the Royal Thai Survey Department, and the Department of Agriculture, have applied satellite remote sensing in their respective fields. The work carried out includes mapping of forest areas, land use patterns, crops and surface water.

For forest mapping, the work has been conducted at the Royal Forest Department. The technique employed has been mainly via visual interpretation. The first maps from Landsat imagery showing the existing forest of the whole country were completed in 1975. The maps at scales of 1:500,000 and 1:1,000,000 are updated on a regular basis, i.e. every two-to-three years. In addition to the study of existing forest and its changes, more work has been done in watershed zoning and management as well as the study of shifting cultivation areas. An important aspect of this application is the recent utilization of satellite-derived information as input for planning and management of forest land-use and forest concession schemes.

One of the mandates of the Department of Land Development is to map land-use patterns for the whole country. With Landsat imagery, existing land-use maps have been updated. Earlier this was done at a rather small scale of 1:1,000,000, 1:250,000 and 1:500,000 through photo-interpretation. For some focal areas where more detailed study is required, digital data analysis has been applied. With the availability of higher resolution imagery, updating maps at a scale of 1:50,000 has been carried out. The updated maps have become a crucial component in the construction of a database for land-use planning purposes.

Crops survey is of great importance for an agricultural country such as Thailand. Conventionally, the Office of Agricultural Economics has employed the area frame sampling technique using photographs for surveying major crops such as rice, sugar cane and corn. Presently, satellite imagery has been used to observe different crops, particularly rice. The Department of Agriculture is also undertaking research in the detection of standing crops such as mangoes from SPOT data. It has been found from a few other studies that agroecological mapping, in which other land and climatic information is incorporated with satellite information, is a far more meaningful approach to crop mapping. However, there is still a need for an effective means of assessing and predicting crop yields using remote sensing techniques.

In the area of map updating, the Royal Thai Survey Department is undertaking the revision of topographic maps - which are more than 20 years old - using satellite images. Although the revised maps may not reach the conventional cartographic standard, users found them useful with new information, particularly on the road networks which are indispensable for people in the field.

Lately, remotely sensed information has played a very important role at the decision-making level. For instance, based on the remaining forest cover as revealed by the satellite images, the Thai Government has banned the forest concession since 1989. In addition, TRSC has been given a mandate to examine the areas under the forest-land reformation scheme before the final decision on reformation is made.

Although satellite data have been more widely used lately and have proven useful for development planning purposes, there remain certain problems that have to be overcome in order for the technology to be much more effectively, if not fully, used. While some of the problems can be tackled with efforts initiated within the country, some require cooperation on a much broader scale. Some major problems encountered in Thailand are noted below.

Cloud cover

Cloud is a critical problem for satellite remote sensing in the visible region of the spectrum. This is particularly true for a tropical country such as Thailand. It has been found that the availability of satellite data is scarce during the rainy season which lasts for about six months a year. This is a crucial obstacle to agricultural surveying due to the fact that most crops are very active during this period. This has stressed the need for all-weather remote sensing capability such as radar or other microwave sensors.

Spatial resolution

Crop patterns in Thailand are very irregular and the field size is generally small. With Landsat Multi-Spectral Scanner (MSS) data of 80 metre resolution, it was difficult to identify small fields and features. The availability of TM and SPOT high resolution visible (HRV) imagery has considerably improved the application in most areas. Therefore, this level of resolution as well as the data continuity should be maintained.

Standardization of data products and end results

Standard formats are important when considering the wide range of remotely sensed data that is available. A compatible format would ease work procedures for users. It would allow users not only to be able to use existing facilities to extract information but also to conduct cross data-set analysis without much difficulty.

The same applies to the standardization of the end results such as the output maps. This is important for the integration of more than one source of information for the purposes of interpolation and analysis in the planning process either manually or automatically.

3. Prospects of remote sensing development

It appears that development trends of remote sensing in the next decade with regard to regional needs may be in the following directions.

Sensor development

Sensors may have to be designed to improve both spectral and spatial resolution. It is likely that sensors for specific fields of application will become better tools than those designed to cover a broad range of targets as presently available. Microwave sensors especially radar would perhaps have an important role for countries in the tropics including Thailand.

Platform development

While a large platform for a multi-purpose payload provides information that is valuable on a global scale, a smaller satellite with a single sensor may better serve the needs of regional communities. Another aspect of these satellites is in terms of orbital characteristics which include the low altitude as well as the equatorial Earth orbits.

Regional aspect of development

With regard to the regional nature of satellite remote sensing, it appears that regional cooperation is becoming very important. Sharing of experiences and costs for countries with common interests will perhaps be a key element. Strengthening of such cooperation and coordination is needed and can be done through already existing mechanisms.

4. Research requirements

Strategic research is needed in the development of remote sensing observation systems appropriate for specific regions and, more importantly, systems that can provide operational applications. The developers of technology therefore play a very important role in providing sound technology choices and in transferring the chosen technology to local users to help build up and strengthen their indigenous capability and expertise both at national and regional levels.

5. Conclusion

The development of remote sensing in Thailand is progressing steadily in areas of satellite data acquisition, distribution and application. It is fortunate that Thailand has been able to keep up with the technology which has developed rapidly. Development trends for the next decade include regional cooperation in all areas. While regional efforts and collaboration are essential, restructuring of national institutions and strengthening of national capability and capacity are also important and have to be developed in parallel with regional development.

B. Marine surveillance and information system: SEAWATCH THAILAND

1. General

SEAWATCH THAILAND is a complete marine environmental monitoring and forecasting system which integrates data collection, data analysis, environmental modelling and forecasting with an advanced computerized system for distribution of marine information and forecasting to interested operators and/or

authorities. This project is being implemented under close cooperation between the National Research Council of Thailand (NRCT) and OCEANOR, an oceanographic company of Norway. The project also involves the Harbour Department, the Meteorological Department, Port Authority of Thailand, Naval Hydrographical Department, Department of Fisheries, the Petroleum Authority of Thailand, Marine Police Division, Chulalongkorn University, Prince of Songkla University and Burapha University among others.

2. Objectives

The objectives for the programme are:

- To set up a database system for marine data and information using integrated technology of satellite remote sensing and real-time data collection from the oceanographic buoy network to monitor oceanographical data, meteorological data and marine environment data.
- To collect and distribute buoy measured data and forecasts to involved organizations in both the private and public sectors for natural resource management.
- To coordinate research with other organizations involved in the field of oceanography and marine resources.
- To collaborate with other organizations in the utilization of buoy-collected data for the natural resource development plan aiming at the sustainable use of marine resources.
- To promote the use of oceanographic data for effective resource management and development.

3. Programme operation

Data acquisition

Real-time data coverage is provided by a network of moored data buoys (called TOBIS buoys). The information obtained includes meteorological parameters (wind speed and direction, air temperature pressure) and oceanographic parameters (oxygen/algae/nutrient contents, waves, currents, temperature/salinity profile, radioactivity). Each buoy has its own data logging equipment, on-board processing (for data analysis and quality control) and transmission system. The collected data are then transmitted to a shore station through the ARGOS communication system on NOAA satellites.

A total of seven buoys are currently deployed in the Gulf of Thailand, each transmitting 6-10 data-sets per day. The buoy positions are shown in table 2.

Table 2. Location of sensor buoys

No.	Buoy position	Longitude	Latitude	First deployment (Date)
1	Sichang Island, Chonburi Province	100.82	13.03	11 Dec. 1991
2	Rayong Bay, Rayong Province	101.22	12.50	12 Dec. 1991
3	Chang Island, Trad Province	102.05	12.14	19 July 1992
4	Plathong Oil Platform, Suratthani Province	101.44	9.70	23 July 1992
5	Tao Island, Chumporn Province	99.99	10.19	11 Feb. 1993
6	Songkhla Bay, Songkhla Province	101.16	7.21	10 March 1993
7	Huahin, Prajuabkirikant Province	100.16	12.50	31 March 1993

Data storage, analysis and presentation

ORKAN is a complete, flexible system for processing, presenting and storing environmental data collected from the buoys. It is supplied with a wide range of modules for data import and export, time and frequency analysis, and presentation tools for graphics and tables.

Environmental modelling and forecasting

Numerical modelling and forecasting software are used for this programme. These include:

NOMAD Model for the simulation of spreading and dilution of aqueous effluents and particulate discharges.

HYBOS Three-dimensional model with a variable curvilinear grid system which, using data on topography, wind fields and tides, simulates water levels, current profiles and circulation in oceans, along coasts (and in fjords) and at sea.

OILSPILL Forecast model for the prediction of drift and the fate of accidental spills at sea.

OILSTAT Graphical presentation of drift times and possible stranding of oil spills from offshore production sites.

4. Distribution of data/forecasts/information

Via the Thainet System

An information system named Thainet allows users easy access to the various buoy-collected data and other information including forecasts, research and news via PC terminals. The communication is two-way, so the distribution system will act as a pool of marine data and information. For buoy-measured data, the users can access the last seven days data from the central database.

The current users of the system are the Meteorological Department; Oceanographic Division, Hydrographic Department; Fisheries Environment Division, Fisheries Department; Aquatic Resources Research Institute, Chulalongkorn University; Faculty of Science and Technology, Prince of Songkhla University; Coastal Resources Institute (CORIN), Prince of Songkhla University; and Marine Survey Division, Port Authority of Thailand.

Direct data distribution

The users can obtain data from any time period by a direct request to NRCT. The format of such data includes the table of parameters, joint occurrence table, time series plot, rose vector diagram, progressive vector diagram and extreme parameter analysis. The data can then be distributed as plots on paper sent by telefax or mail, or as files saved on diskettes.

5. Advantages of SEAWATCH THAILAND

SEAWATCH data has been used for a variety of projects.

Planning, managing and monitoring aquaculture plants and commercial fishing

Results from the models can be combined with information from other sources to generate suitability maps of fish-farm locations and fishing spots, which in turn help fishermen save money and man-power normally spent on random search.

Thainet provides information on weather conditions and also impending changes in the sea and/or advance warning of pollution threats such as oil slicks, poisonous algae, jellyfish and substandard water quality and additionally provides advice on countermeasures.

Environmental preservation for the tourist industry and future generations

Some of Thailand's coastal "treasures", namely beaches, coral reefs and mangrove forests are being threatened by tourism, construction and environmental pollutants. Using SEAWATCH information, environmental monitoring and protection plans can be set up in order to conserve and maintain these national resources.

Providing design parameters for onshore and offshore structures

Environmental data is usually necessary for establishing design parameters for feasibility studies and designs of projected locations for production platforms, pipeline routes, harbours and oil terminals, and breakwaters etc. This information includes data on wind, waves, currents, rate of marine growth and rate of corrosion.

Analysis of marine pollution from sewage outfalls, industry and offshore installations

The SEAWATCH system can be used to monitor water quality and organisms in the study area, and aid in the assessment of long-term effects of environmental pollutant. Environmental investigations, such as how a given pollutant will dilute and spread, how it will affect organisms in the area and how much of the pollutant the environment can absorb without harm, can be carried out.

Weather forecasts

Since each buoy carries its own meteorological station, the measured parameters can be used with data from other stations and/or other sources in the forecasting process.

6. Conclusion

The SEAWATCH THAILAND programme is being established through the networking of data-collection buoys. The observed data can be integrated with data from other sources or used as an input to various numerical models. Results from the models can be further combined with the information from the buoy network to produce user-oriented forecasts. The distribution of marine environmental data and forecasts is a PC-based system that allows users to log on and retrieve the information directly.

TURKEY

[Original: English]

Space-related activities in 1994

The main space event in Turkey in 1994 was the successful launch of TURKSAT 1B in July as the first Turkish communications satellite in orbit. TURKSAT 1B was placed at its assigned geosynchronous position at 42 degrees east longitude, by an Arianne IV rocket launched from Korou in French Guiana. The first satellite in the series, TURKSAT 1A, was lost in a launch failure earlier in the year. TURKSAT 1C will replace that tailed satellite at 31 degrees east longitude in a launch planned for 1996. Built by the French company Aerospatiale, TURKSAT 1B has 16 transponders operating in the Ku band with 14.00-14.51 GHz uplink and 10.95-11.20 and 11.45-11.70 GHz downlink. The three main geographic regions of western Europe, Turkey and Central Asia, are illuminated with a peak power level of 55 watts which allows TV reception in these areas with a 60 cm to 80 cm diameter dish antenna. With a mass of 1,070 kg TURKSAT 1B has a design life of a minimum of 10 years which is now expected to be 12 years. The satellite will be used for a variety of services including TV transmission, telephone, data, VSAT and mobile communications.

There was an increase in 1994 in the use of remotely sensed satellite data and geographic information systems. What had previously been confined mostly to university and research work has been finding more and more applications in operational government developments. The mapping of soil erosion is a notable project started in 1994, funded by the Foundation for Combatting Soil Erosion (TEMA). The GIS market is poised to experience a major expansion in the near future.

The Turkish Space Sciences Community is participating in the international scientific satellite experiment "Spectrum X-Gamma" with several scientific research groups from different countries, including Denmark, France, Israel, Russian Federation, Turkey, United Kingdom and others. Parts of the experiment is being built by the various groups of different countries, and the Russian Federation, with the largest share in the total experiment, is coordinating and assembling various components under a joint platform. The Turkish team has participated in the calibration and assembly procedures of some of the Spectrum X-experiments.

One other facility for the Turkish astronomers and space sciences community is the National Optical Observatory being built at Southwestern Taurus Mountains at a height of 2,400 m. A 2-metre radio telespace system (with a Shottky - diode uncooled spectrometer) sensitive to 85-115 GHz (millimetre wavelength) radio emission from celestial radio sources has also been commissioned. The telescope (dubbed as MRT -2) will be dedicated in January 1995 and the first research programme is planned for the observations of some galactic molecular clouds where strong carbon monoxide (CO), hydrogen cyanide (HCN) and other emissions are expected. These and other species of greenhouse gases are also present in the Earth's atmosphere. Use of the telescope for their observation, as well as observation of the Sun, is also envisioned.